PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 13 July 2001 (13.07.01)	
International application No. PCT/US00/28367	**Applicant's or agent's file reference** 001179
International filing date (day/month/year) 13 October 2000 (13.10.00)	**Priority date** (day/month/year) 15 October 1999 (15.10.99)
Applicant RAMUN, John, R.	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

19 March 2001 (19.03.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer H. Zhou
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/28367

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B02C 1/00
US CL : 241/101.73, 266; 30/134
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 241/101.73, 266; 30/134

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,738,289 A *(TAGAWA)* 14 April 1998, See Figure 1	1-75
X	US 5,636,802 A *(TAGAWA)* 10 June 1997, See Figure 3	1-75
X	US 4,890,798 A *(TAGAWA et al.)* 02 January 1990, See Figure 1	1-75
Y	US 5,243,761 A *(SULLIVAN et al.)* 14 September 1993, See Figure 4	1-75

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
21 DECEMBER 2000

Date of mailing of the international search report
25 JAN 2001

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
WILLIAM HONG
Telephone No. (703) 308-1148

Sheila Veney
Paralegal Specialist
Technology Center 3700

Form PCT/ISA/210 (second sheet) (July 1998)★

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
001179		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US00/28367	13 OCTOBER 2000	15 OCTOBER 1999
International Patent Classification (IPC) or national classification and IPC IPC(7): B02C 1/00 and US Cl.: 241/101.73, 266; 30/134		
Applicant RAMUN, JOHN R.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 0 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
19 MARCH 2001	29 NOVEMBER 2001
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer ALLEN OSTRAGER Sheila Veney Paralegal Specialist Technology Center 3700
Facsimile No. (703) 305-3230	Telephone No. (703) 308-1745

Form PCT/IPEA/409 (cover sheet) (July 1998)★

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/28367

I. Basis of the report

1. With regard to the elements of the international application:*

[X] the international application as originally filed.

[X] the description:
pages: 1-26 as originally filed
pages: NONE filed with the demand
pages: NONE, filed with the letter of

[X] the claims:
pages: 27-40 as originally filed
pages: NONE as amended (together with any statement) under Article 19
pages: NONE filed with the demand
pages: NONE, filed with the letter of

[X] the drawings:
pages: 1-33 as originally filed
pages: NONE filed with the demand
pages: NONE, filed with the letter of

[X] the sequence listing part of the description: NONE as originally filed
pages: NONE filed with the demand
pages: NONE, filed with the letter of

2. With regard to the language, all the elements marked above were available or furnished to the Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to the Authority in the following language _____ which is:

[ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b))

[ ] the language of publication of the international application (under Rule 48.3(b)).

[ ] the language of the translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3)

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

[ ] contained in the international application in printed form

[ ] filed together with the international application in computer readable form

[ ] furnished subsequently to this Authority in written form

[ ] furnished subsequently to this Authority in computer readable form

[ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

[X] The amendments have resulted in the cancellation of:

[X] the description, pages: None

[X] the claims, Nos.: None

[X] the drawings, sheets/fig: None

[ ] This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).*

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/28367

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	NONE	YES
	Claims	1-75	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-75	NO
Industrial Applicability (IA)	Claims	1-75	YES
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claims 1-75 LACK novelty under PCT Article 33(2) as being anticipated by Tagawa. Tagawa discloses all the clined limitations for a demolition tool including: a universal body; a pair of pivotable blades; at least one link attached to each blade; a slide member; a piston; a pivot pin; and a quick change assembly connector. Although the pivot pin is not in common with each each link; it is certainly within the general skill of one in the art to combine the two pivot pins to one as a matter of design choice.

---------- NEW CITATIONS ----------

NONE

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: RICHARD L. BYRNE
WEBB ZIESENHEIM LOGSOON
ORKIN & HANSON PLC
700 KOPPERS BUILDING
436 SEVENTH AVENUE
PITTSBURGH PA 15219-1818

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

	Date of Mailing *(day/month/year)* 23 JAN 2002
Applicant's or agent's file reference 001179	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority Date *(day/month/year)*
PCT/US00/28367	13 OCTOBER 2000	15 OCTOBER 1999

Applicant
RAMUN, JOHN R.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer WILLIAM HONG for Sheila Venoy Paralegal Specialist Technology Center 3700
Facsimile No. (703) 305-3230	Telephone No. (703) 308-1148

Form PCT/IPEA/416 (July 1992)★

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
001179		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US00/28367	13 OCTOBER 2000	15 OCTOBER 1999
International Patent Classification (IPC) or national classification and IPC IPC(7): B02C 1/00 and US Cl.: 241/101.73, 266; 30/134		
Applicant RAMUN, JOHN R.		

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2. This REPORT consists of a total of 3 sheets.

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3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability

   IV ☐ Lack of unity of invention

   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI ☐ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
19 MARCH 2001	29 NOVEMBER 2001
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer for ALLEN OSTRAGER Sheila Veney Paralegal Specialist Technology Center 3700
Facsimile No. (703) 305-3230	Telephone No. (703) 308-1748

Form PCT/IPEA/409 (cover sheet) (July 1998)★

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/28367

I. Basis of the report

1. With regard to the elements of the international application:*

[X] the international application as originally filed

[X] the description:
pages: 1-26 as originally filed
pages: NONE , filed with the demand
pages: NONE , filed with the letter of

[X] the claims:
pages: 27-40 , as originally filed
pages: NONE , as amended (together with any statement) under Article 19
pages: NONE , filed with the demand
pages: NONE , filed with the letter of

[X] the drawings:
pages: 1-33 , as originally filed
pages: NONE , filed with the demand
pages: NONE , filed with the letter of

[X] the sequence listing part of the description: NONE as originally filed
pages: NONE , filed with the demand
pages: NONE , filed with the letter of

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

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[ ] the language of publication of the international application (under Rule 48.3(b)).

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3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international

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[ ] filed together with the international application in computer readable form

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readable form

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4. [X] The amendments have resulted in the cancellation of:

[X] the description, pages: None

[X] the claims, No.: None

[X] the drawings, sheets: ~~his~~ None

[ ] This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

*** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRE[redacted]INARY EXAMINATION REPORT

([redacted]ational application No.
PCT/US00/28367

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	NONE	YES
	Claims	1-75	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-75	NO
Industrial Applicability (IA)	Claims	1-75	YES
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claims 1-75 LACK novelty under PCT Article 33(2) as being anticipated by Tagawa. Tagawa discloses all the climed limitations for a demolition tool including: a universal body; a pair of pivotable blades; at least one link attached to each blade; a slide member; a piston; a pivot pin; and a quick change assembly connector. Although the pivot pin is not in common with each each link; it is certainly within the general skill of one in the art to combine the two pivot pins to one as a matter of design choice.

NEW CITATIONS

NONE

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 April 2001 (26.04.2001)

PCT

(10) International Publication Number
WO 01/28687 A1

(51) International Patent Classification[7]: B02C 1/00

(21) International Application Number: PCT/US00/28367

(22) International Filing Date: 13 October 2000 (13.10.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/159,869 15 October 1999 (15.10.1999) US
60/195,797 10 April 2000 (10.04.2000) US

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(74) Agents: BYRNE, Richard, L. et al.; Webb Ziesenheim Logsdon Orkin & Hanson, P.C., 700 Koppers Building, 436 Seventh Avenue, Pittsburgh, PA 15219-1818 (US).

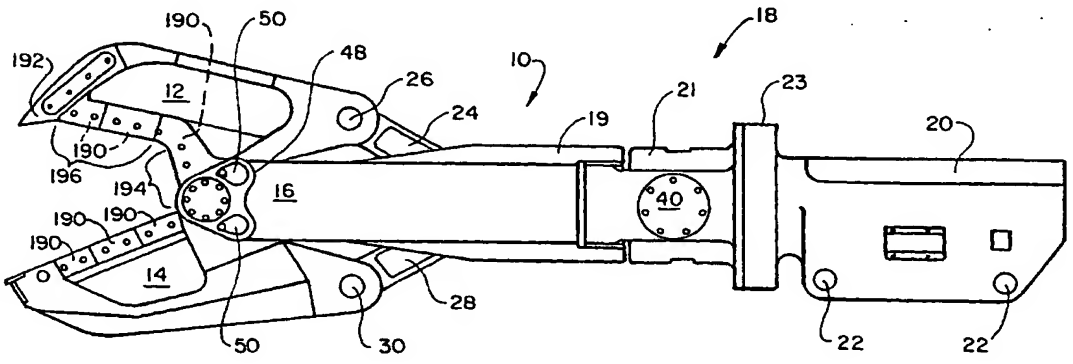
(81) Designated States (national): AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— With international search report.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: MULTIPLE TOOL ATTACHMENT SYSTEM



(57) Abstract: A multiple attachment system is adapted to be attached to demolition equipment. The system includes a universal body (18) attached to the demolition equipment. A series of tools are independently attached to the universal body. The universal body includes a guide slot (44) extending longitudinally along the universal body. Each tool includes a pair of pivotable jaws (12, 14) adapted to be pivotably attached to the universal body with at least one linkage (24, 28) extending from the universal body and attachable to each jaw of the tool. A slide member (32) is received within the guide slot, with each linkage attached to the slide member, and a piston cylinder arrangement (38) is attached to the universal body and coupled to the slide member for moving the slide member and the jaws. The multiple tool attachment system is provided with quick change features and is designed to optimize the cutting characteristics throughout the movement cycle.

WO 01/28687 A1

MULTIPLE TOOL ATTACHMENT SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a tool attachment system for construction or demolition equipment which is adapted to be attached to a backhoe for attaching multiple tools, such as a heavy-duty metal cutting shear, a plate shear, a concrete crusher, a grapple or the like. More particularly, the present invention relates to a multiple tool attachment system for attaching tools having plural movable jaws.

2. Background Information

The present application refers to demolition equipment, however, the equipment is also referred to as construction equipment, scrap handling equipment and the like. The description of demolition equipment or construction equipment is not intended to be restrictive of the equipment being referenced. Demolition equipment, such as heavy-duty metal cutting shears, grapples and concrete crushers, have been mounted on backhoes powered by hydraulic cylinders for a variety of jobs in the demolition field. This equipment provides for the efficient cutting and handling of scrap. For example, in the dismantling of an industrial building, metal scrap in the form of various diameter pipes, structural I-beams, channels, angles, sheet metal plates and the like, must be efficiently severed and handled by heavy-duty metal shears. Such shears can also be utilized for reducing automobiles, truck frames, railroad cars and the like. The shears must be able to move and cut the metal scrap pieces regardless of the size or shape of the individual scrap pieces and without any significant damage to the shears. In the demolition of an industrial building, concrete crushing devices, such as a concrete pulverizer or concrete crackers, are also used to reduce the structure to manageable components which can be easily handled and removed from the site. Wood shears and plate shears also represent specialized cutting devices useful in particular demolition

or debris removal situations depending on the type of scrap. Also, a grapple is often utilized where handling of debris or work pieces is a primary function of the equipment. Historically, all of these pieces of equipment represent distinct tools having significant independent capital cost. Consequently, the demolition industry has tended to develop one type of tool that can have the greatest possible utility and application.

With regard to metal shears, one type of known shear is a shear having a fixed blade and a movable blade pivoted thereto. The movable blade is pivoted by hydraulic cylinder to provide a shearing action between the blades for severing the work pieces. Examples of this type of shear can be found in my prior U.S. Patent Nos. 4,403,431; 4,670,983; 4,897,921; 5,926,958; and 5,940,971 which are incorporated herein by reference.

The prior art has also developed a variety of demolition tools utilizing a plurality of movable jaws. U.S. Reissue Patent No. 35,432 and U.S. Patent No. 5,060,378 both disclose heavy-duty metal cutting shears having a body and a pair of movable jaws mounted to the frame for pivoting about a common point. Each jaw includes a plurality of cutting inserts in shearing relation with the inserts on the other jaw, with one jaw forming a slot for maintaining the inserts in shearing relation to each other throughout the cutting movement. Each jaw is operated by an independent hydraulic cylinder. The jaw configuration provides a hook-shaped structure with one of the jaws having a cutting or piercing tip at the end thereof. However, these patents do not optimize the jaw structure for the purpose of cutting. Additionally, the independent cylinders increase the cost and prevent a compact shear design.

U.S. Patent No. 5,359,775 discloses a metal cutting shear with a pair of movable jaws pivotally mounted to a frame with a pair of jaws operated off of a common piston extending between the jaws.

U.S. Patent Nos. 4,838,493; 4,890,798; 5,044,569; 5,636,802; and 5,738,289 all disclose a variety of concrete crushers having a plurality of movable jaws operated through hydraulic cylinders. U.S. Patent Nos. 4,903,408; 5,044,568; 5,199,658; 5,243,761; and 5,626,301 also disclose a variety of demolition equipment having a plurality of movable jaws.

The prior art does not provide a system for easily changing tools or a system which allows complete separate tools to efficiently share a common structure. Further, the prior art fails to optimize the jaw structure utilized in the individual tools, such as metal cutting shears, to maximize power and efficiency. Additionally, the prior art provides a complex arrangement for rotations of the tool and jaws without sufficient protection for any hydraulic cylinder powering the working jaws.

SUMMARY OF THE INVENTION

The object of the present invention is to overcome the aforementioned drawbacks of the prior art. It is a further object of the present invention to provide a multiple tool attachment system which is easily converted between a plurality of distinct tools. A further object of the present invention is to provide a demolition tool having a plurality of movable jaws which optimizes the jaw structure. A further object of the present invention is provide a demolition tool which optimizes the ratio between the jaw and the jaw power structure to provide optimum power performance throughout the blade movement cycle. A further object of the present invention is to provide a demolition tool system that simplifies the construction of the tool system, including rotating tools. A further object of the present invention is to provide a method for designing a demolition tool and tool system.

The objects of the present invention are achieved by a multiple tool attachment system according to the present invention. The attachment system is adapted to be attached to demolition equipment, also referred to as construction

equipment, scrap handling equipment and the like. The system includes a universal body attachable the demolition equipment, a hydraulic cylinder attached to the universal body, a pair of linkages adapted to be coupled with the hydraulic cylinder, and a plurality of demolition tool units each selectively, removably attachable to the body and the hydraulic cylinder.

Each tool unit includes a pair of pivotable blades or jaws adapted to be pivotally connected to the body and to the pair of linkages. In one embodiment, the tool unit includes a pair of movable blades pivoted together with a common pivot pin connecting the blades together, and a bridge housing coupled to the pivot pin providing a quick release system for attaching the tool set to the body.

In one embodiment of the invention, the universal body includes a guide slot extending longitudinally along the body. A slide member is received within the guide slot, with each linkage attached to the slide member and the piston cylinder arrangement attached to the body and coupled to the slide member for moving the slide member and the blades. The linkages may be attached to the slide member at a common point. Additionally, the linkages may have a common sleeve adapted to hold the linkages together when decoupled from the slide member. The universal body may be provided with pivotable sides and/or with side access panels to assist in repair, maintenance and tool changing.

The demolition equipment is provided with quick change features and is designed to optimize the cutting characteristics throughout the movement cycle. Specifically, the lengths of the linkages and the lengths of the relevant lever arms for each blade of a tool set may be set to be substantially equal or varied. In general, these jaw and link dimensions may be selected for a desired positioning of the power curve of the jaw to optimize the performance throughout the intended operating conditions. The jaw and link dimensions may be selected to shape or regulate the power

curve in a desired manner. For example, the relative dimensions of the jaw sets may be selected to provide an increasing power curve throughout the blade closing motion or, alternatively, the relative dimensions of the jaw sets may be selected to have the power curve peak slightly before the end of the blade closing motion. In one shear of the present invention, the jaw depth and maximum jaw opening are also the same as the lever arm and linkage lengths. Additionally, the jaw design of the shear of the present invention is designed to perform the majority of the heavy cutting at the throat of the plural moving jaws. The concepts of the present invention can be incorporated into a guided single moving blade demolition tool.

These and other advantages of the present invention will be clarified in the description of the preferred embodiments wherein like reference numerals represent like elements throughout.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view illustrating a heavy-duty shear according to the present invention incorporated into a universal body for a construction tool system according to the present invention;

Fig. 2 is a side view of a shear similar to the shear of Fig. 1 without a rotator in the body;

Fig. 3 is a side view of the shear in Fig. 1 with an outer side panel of the body removed;

Fig. 4 is a sectional view taken along line A-A of Fig. 3;

Fig. 5 is a plan view of the shear in Fig.1;

Fig. 6 is an enlarged plan view, partially in section, of a slide member of the universal body according to the present invention;

Fig. 7 is a side view of the slide member illustrated in Fig. 6;

Fig. 8 is a plan view, partially in section, of a main shaft assembly of a tool unit mounted on the universal body of the construction tool system shown in Fig. 1;

Figs. 9-11a sequentially illustrate the disassembly of a tool unit mounted on the universal body of the construction tool system shown in Fig. 1;

Fig. 11b is a front view of a modified bridge of the quick change system of the present invention;

Fig. 11c is an exploded view of the quick change system used with the modified bridge of Fig. 11b;

Fig. 11d is a side view of a keeper pin used in the quick change system of Figs. 11b-c;

Fig. 12 is a side view of a plate shear according to the present invention incorporated into the universal body of Fig 1;

Fig. 13 is a front view of the plate shear illustrated in Fig. 12;

Fig. 14 is a side view of a concrete cracker according to the present invention incorporated into the universal body of Fig. 1;

Fig. 15 is a front view of the concrete cracker illustrated in Fig. 14;

Fig. 16 is a side view of a concrete pulverizer according to the present invention incorporated into the universal body of Fig.1;

Fig. 17 is a front view of the concrete pulverizer illustrated in Fig. 16;

Fig. 18 is a side view of a wood shear according to the present invention incorporated into the universal body of Fig. 1;

Fig. 19 is a front view of the wood shear illustrated in Fig. 18;

Fig. 20 is a side view of a grapple according to the present invention incorporated into the universal body of Fig. 1;

Fig. 21 is a front view of the grapple illustrated in Fig. 20;

Fig. 22 is a side view of an iron and rail cracker according to the present invention incorporated into the universal body of Fig. 1;

Fig. 23 is a front view of the iron and rail cracker illustrated in Fig. 22;

Fig. 24 is a sectional view of the universal body illustrated in Fig. 1 taken along line A-A of Fig. 5;

Fig. 25 is a sectional view of a hydraulic cylinder for the universal body of the present invention;

Fig. 26 is a side view schematically illustrating a jaw and a linkage arrangement of the shear of Fig. 1;

Fig. 27a is a graph of the power curve and relative jaw position for a shear having the linkage arrangement according to Fig. 26;

Fig. 27b is a graph of the power curve of a shear designed according to the present invention to have the power curve peak near the end of the jaw motion;

Fig. 28 is a side view similar to Fig. 1 illustrating a heavy-duty shear according to another embodiment of the present invention;

Fig. 29 is a top view of the shear illustrated in Fig. 28;

Fig. 30 is a sectional view of the shear illustrated in Fig. 28;

Figs. 31-34 sequentially illustrate the disassembly of a tool unit mounted on a universal body illustrated in Fig. 28;

Fig. 35 is a side view of the shear according to Fig. 28 incorporated into a modified universal body;

Fig. 36 is a plan view of a modified universal body according to the present invention;

Fig. 37 is a plan view of another modified universal body according to the present invention;

Fig. 38 is a side view of the universal body illustrated in Fig. 37;

Fig. 39 is a side view of the shear according to Fig. 28 incorporated into a modified universal body;

Fig. 40 is a plan view of the universal body illustrated in Fig. 39;

Fig. 41 is a schematic side view of a shear according to the present invention incorporated into a further modified universal body;

Fig. 42 is a schematic side view of a jaw portion of a shear according to the present invention;

Fig. 43 is a side view, partially in section, of a shear according to the present invention incorporated into a further modified universal body;

Fig. 44 is a side view of a shear according to the present invention;

Fig. 45 is a side view, with a front side removed for clarity, of the shear illustrated in Fig. 44;

Fig. 46 is a sectional view taken along line A-A of Fig. 45;

Fig. 47 is a schematic side view of a shear according to the present invention; and

Fig. 48 is a schematic side view of the shear illustrated in Fig. 47 in the closed position;

Fig. 49 is a side view, partially in section, of a shear according to the present invention incorporated into a further modified universal body;

Fig. 50 is a rear view of a rotary coupling of the shear in Fig. 49;

Fig. 51 is an enlarged view of a connector pin assembly for the rotary coupling in Fig. 50;

Fig. 52 is a side view of an adapter of the shear in Fig. 49;

Fig. 53 is a front view of the adapter of Fig. 52;

Fig. 54 is a side view, partially in section, of a shear similar to the shear of Fig. 49 without a rotary coupling in the body; and

Fig. 55 is a side view, partially in section, of a shear similar to the shear of Fig. 49 and formed as a stick mounted type shear.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 illustrates a multiple tool attachment according to the present invention adapted to be attached to demolition equipment, such as a backhoe (not shown). The multiple tool attachment is adapted to connect one of a series of tools or tool units to the demolition equipment.

Fig. 1 illustrates a shear 10 coupled to the multiple tool attachment. The shear 10 includes a first blade 12 and second blade 14 pivotally connected at a hub or main pin 16 to a universal body 18. The universal body 18 is referred to as the universal body 18 because it remains common to a series of tools or tool units in the attachment system according to the present invention. The universal body 18 is comprised of sides 19, bearing housing 20 and yoke 21. The main pin 16 provides a common pivot for both the first blade 12 and second blade 14.

The bearing housing 20 includes spaced mounting apertures 22 for attaching the universal body 18 to the demolition equipment in a conventional fashion through an adaptor (not shown). The adaptor will pivotally connect the universal body 18 to the demolition equipment and to a controlling piston for pivoting of the universal body 18. The adapter is intended to conform to the specific demolition equipment such that the shape of the adapter will differ depending on the specific demolition equipment utilized.

A rotary coupling 23 is between the bearing housing 20 and the yoke 21. The rotary coupling 23 allows for a rotation of the remaining portions of the universal body 18 relative to the bearing housing 20 and the associated demolition equipment. Essentially, the rotary coupling 23

allows for 360 degree rotation for angular orientation of the universal body 18 and associated tool such as shear 10. A motor 25, as shown in Fig. 5, is attached to the bearing housing 20 and geared to the rotary coupling 23 for rotationally positioning the universal body 18.

Fig. 2 illustrates a shear 10' similar to shear 10 illustrated in Fig. 1. The shear 10' has a modified universal body 18' that does not include a rotary coupling attached to the bearing housing 20. A bearing housing 20' and a yoke 21' are of a unitary construction. The universal body 18' is appropriate where no rotation of the tool is desired.

As best shown in Fig. 3, a first linkage 24 is pivotally connected at a removable pivot pin 26 to the first blade 12 and a second linkage 28 is pivotally connected at a removable pivot pin 30 to the second blade 14. The first linkage 24 and second linkage 28 are pivotally connected to a slide member 32 at a common pivot pin 34. The slide member 32 is attached to a piston rod 36, as shown in Fig. 25, which is movable by a double-acting hydraulic cylinder 38 (shown in the universal body 18 in Fig. 30). The hydraulic cylinder 38 is pivotally attached to the universal body 18 through trunnion 40. The details of the hydraulic cylinder 38 are shown in Figs. 24 and 25 and are described in detail below.

As shown in Figs. 3 and 4, sides 19 of the universal body 18 include a longitudinally extending slot or groove 44 which receives and guides the slide member 32 as shown in Fig. 4. The pivot pin 34 for connecting the first linkage 24 and second linkage 28 to the slide member 32 is aligned with the piston rod 36 and hydraulic cylinder 38 as illustrated in the figures. Having the linkages 24 and 28 attached to the slide member 32 at a common point in-line with the hydraulic cylinder 38 helps maximize the power and efficiencies of the tool, such as shear 10, while minimizing the detrimental forces acting on the hydraulic cylinder 38. Additionally, the guiding of slide member 32 within a slot 44

resists torsional forces which otherwise disrupt the action of the tool and the operation of the hydraulic cylinder 38. The structure of the slide member 32 is shown in detail in Figs. 4 and 6-7 and will be described in detail below.

A significant feature of the multiple tool attachment of the present invention is the quick change design incorporated into the connection between the jaw set of a specific tool and the universal body 18. This connection and the process of disassembly is shown in Figs. 9-11a. A bridge housing 48 surrounds the main pin 16 and is utilized for quickly and easily attaching the main pin 16 and the associated jaw set to the universal body 18. Specifically, the sides 19 include receiving members 42 at the ends thereof which are adapted to be received in grooves in the bridge housings 48 for attaching the universal body 18 to the bridge housing 48. Keeper pins 50 are received through apertures 52 in the bridge housing 48 and the receiving members 42. Keeper screws or bolts 54 can be used to secure each keeper pin 50 to one bridge housing 48. In this arrangement, the outer bearing structure surrounding the main pin 16 will remain affixed even when the tool unit is removed from the universal body 18. This provides the advantage that all the bearing or rotating surfaces will be protected from dirt and grit even when the tool unit is disassembled. A modification of the quick connecting system is shown in Figs. 11b-d. Figs. 11b and 11c show a modified bridge housing 48' which receives keeper pins 50' in apertures 52 in the bridge housing 48'. The keeper pins 50' are held in place by the keeper 54' as shown in Fig. 11c. Specifically, the shaft of the keeper 54' is received in a locking groove 55 formed in the keeper pins 50' as shown in Fig. 11d. Figs. 11b-d illustrate that various modifications may be made to the quick change system within the scope of the present invention. Each keeper 54' is held in place by a retainer 55', such as a threaded plug or the like.

The quick change design of the present invention allows the universal body 18 to accommodate a wide variety of tool units. For example, the shear 10 formed by the first blade 12 and second blade 14 can be replaced with a plate shear 100 illustrated in Figs. 12 and 13 having distinct blades 102 and 104. The plate shear 100 is similar to shear 10 except that the jaw of blades 102 and 104 is specifically designed for cutting plate. The plate shear 100 is similar to the shear 10 in that it is specifically designed for cutting metal products.

Figs. 18 and 19 illustrate a wood shear 110 utilized with the universal body 18 of the present invention. Wood shear 110 includes blades 112 and 114 specifically designed for cutting wood products.

Figs. 14 and 15 illustrate a concrete cracker 120 for use with the universal body 18. The concrete cracker 120 includes jaws 122 and 124 designed specifically for cracking concrete structures. Each jaw 122 and 124 includes concrete crushing inserts 126 at a distal end thereof cooperating with the crushing insert 126 on an opposite jaw 122 or 124 as well as cutting inserts 70 adjacent the main pin 16 which provide a shearing relationship with the cutting inserts 70 of the associated jaw 122 or 124.

Figs. 16 and 17 illustrate a concrete pulverizer 130 for use with the universal body 18 of the present invention. The concrete pulverizer 130 includes jaws 132 and 134 associated with crushing of concrete. The jaws 132 and 134 include crushing inserts 126 cooperating with inserts 126 on an opposite jaw 132 and 134.

Figs. 20 and 21 illustrate a grapple 140 for use with the universal body 18 of the present invention. The grapple 140 includes jaws 142 and 144 having hook-shaped tines 146 extending from each jaw 142 and 144. The tines 146 of each jaw 142 and 144 are designed to extend between spaces of the tines 146 on the opposed jaw 142 or 144 such that the

tines 146 can overlap in a closed position to completely encircle the work piece.

Figs. 22 and 23 illustrate an iron and rail cracker 150 for use with the universal body 18 of the present invention. The iron and rail cracker 150 includes jaws 152 and 154 having interposed inserts 156 thereon. The iron and rail cracker 150 is designed to crack rail and cast iron products, such as engine blocks and the like.

The series of tools illustrated in the figures is merely intended to be representative of the tools which can be designed for use with the universal body 18. The quick disconnect feature provided by the bridge housing 48 on each tool facilitates the rapid tool change of the present invention. It will be appreciated that the linkages 24 and 28 must also be disconnected during the change. This is easily accomplished through removal of the respective pivot pins 26 and 30. Consequently the linkages 24 and 28 can be considered part of the universal body 18 since these are likely to be common to multiple tool sets. It is also possible to change out the linkages with the tool sets by either disconnecting the linkages 24 and 28 from the slide member 32 or disconnecting the slide member 32 from the hydraulic cylinder 38. This may be desired where a tool set requires a change in the linkage lengths. Different tools may have different respective linkage lengths.

Due to the rotation of the forward portions of the universal body 18 through the rotary coupling 23, the rotation must be addressed in the hydraulic cylinder 38 and the hydraulic lines leading thereto. The hydraulic cylinder 38 is provided as a combined hydraulic cylinder and rotary joint to accommodate the provision of the rotary coupling 23. As shown in Figs. 24 and 25, the hydraulic cylinder 38 includes a cylinder housing 160 which is rotatable with the universal body 18 through the trunnion 40. The cylinder housing 160 includes a cylinder extension 162 attached thereto which includes hydraulic lines 164 and 166

appropriately coupled for driving opposite ends of a piston 168 within the cylinder housing 160. The piston rod 36 is attached to the piston 168. The cylinder extension 162 is received within a stationary housing 170 which is secured to the bearing housing 20. The stationary housing 170 includes hydraulic ports 172 and 174 communicating with respective hydraulic lines 164 and 166. As illustrated in Fig. 25, the hydraulic ports 172 and 174 are channels around the interior of stationary housing 170 which provides constant fluid communication between the hydraulic ports 172 and 174 and the associated hydraulic lines 164 and 166 throughout rotation of the cylinder extension 162 relative to the stationary housing 170. Hydraulic lines 176 and 178 extend from the ends of hydraulic lines 164 and 166 to the appropriate interior portions of the cylinder housing 160 as shown in Fig. 25. This design of the hydraulic cylinder 38 accommodates the provision of a rotary coupling 23 without the need for a separate rotary joint. This design also provides a far more compact arrangement for the universal body 18 than if a separate rotary joint were utilized.

Fig. 26 illustrates the geometric relationships of the shear 10 according to the present invention. As illustrated in Fig. 26, the relevant parameters for the shear 10 include the lengths of each linkage 24 and 28 and lever arms 180 and 182 of the first blade 12 and second blade 14, respectively. The lever arms 180 and 182 for each blade 12 and 14 is the distance between the respective pivot pins 26 and 30 and the main pin 16. Further parameters include the jaw depth defined as the distance between the tip of the jaw and the innermost usable portion of that jaw and the maximum shear opening between the respective ends of the first blade 12 and second blade 14 as illustrated in Fig. 26. The shear 10 of the present invention optimizes the operational characteristics by analyzing and setting these dimensions to properly position the associated power curve. For example, in one embodiment, the power curve shown in Fig. 27a is set

to continuously increase throughout the jaw movement by providing the shear opening, the shear jaw depth, the knife lever arm and links having substantially the same dimensional lengths. Maintaining these elements as substantially equal may help maximize the jaw opening as well as jaw depth and available shear tonnage. The present invention provides for the shaping and regulation of the power curve by selecting the relative dimensions accordingly. For example, Fig. 27b shows the power curve for one embodiment of the present invention in which the dimensions are selected so that the power curve peaks near the end of the cutting motion.

The cutting effort for each blade 12 or 14 as a function of the linkage geometry utilized in the shear 10 is calculated according to the following equation:

Cutting Effort=(Lever Arm) x (Cylinder Force/2) x $\sin(\beta)/\cos(\theta)$; wherein β is the angle between the lever arm 180 and 182 and the associated linkage 24 or 28 and θ is the angle between the longitudinal axis of the cylinder 38 and the respective linkage 24 or 28.

The cutting force produced by the shear 10 at any location along the shear cutting edge can be calculated by dividing the cutting effort by the distance measured from the main pin 16 to the desired location along the blade 12 or 14. In order to optimize the geometric parameters of the shear 10 according to the present invention, the above parameters were varied and the resulting cutting torques where studied. The cutting torque is defined as the torque applied to the respective blade 12 or 14 about the main pin 16 by the hydraulic cylinder 38 through the piston rod 36, slide member 32 and associated linkage 24 or 28. This torque can be converted to a single force along the blade 12 or 14 by dividing the torque by the distance from the center of the

main pin 16 to the desired location on the blade 12 or 14. The numerical value of the cutting torque is at its minimum when the blades 12 and 14 are fully open. The torque continuously increases in value as the blades 12 or 14 move to the fully closed position. Fig. 27a illustrates the favorable cutting force or power curve achieved with one shear of the present invention. Fig. 27a illustrates the force generated at the throat and piercing tip for the shear 10 through the various jaw positions which is shown in the lower portion of the graph. It is of particular importance to note that the power curve of this shear continually increases throughout the jaw closing cycle. The jaw position is graphed as the distance between the piercing tip and the lower jaw with the negative values reflecting when the portions of the upper jaw are moving through a slot in the lower jaw. The relative dimensions of the jaw parameters can be selected to vary the power curve as desired. For example, it may be advantageous to have the power curve peak slightly before the end of the jaw cycle when the maximum cutting forces are needed such as shown in Fig. 27b. Providing the linkage lengths slightly greater than the lever arms may be used to achieve this design.

A review of the effect of changing the relevant parameters will clarify the advantages of the design of the shear 10 of the present invention as well as the tool design method of the present invention. Increasing the length of the lever arm 180 or 182 of the respective blade 12 or 14 results in the increased values of cutting torque for all positions of the blade 12 or 14 from fully open to fully closed. However, the length of the respective lever arm 180 and 182 is, of course, limited by the desired overall dimensions of the shear 10. Varying the length of the linkages 24 and 28 has various effects on the cutting torque. If the linkages 24 and 28 are longer than the respective lever arms 180 and 182, the cutting torque curve versus the blade 12 and 14 position will increase in value until

reaching a peak and then decreasing until the blades 12 and 14 are closed. One embodiment of the present invention utilizes this concept to position the maximum cutting torque near the end of the jaw moving cycle. If the length of the linkages 24 and 28 are shorter than the respective lever arms 180 and 182, the torque value will continuously increase from the open to the closed position. As the length of the linkage arms 24 and 28 increases, the value of the cutting torque at the open position increases and the value of the closed position decreases. Having the linkages 24 and 28 substantially the same length as the lever arms 180 and 182 results in one shear design which considers all of the factors to be balanced.

The hydraulic cylinder 38 also has an effect on the power of the associated shear 10. Increasing the diameter of the hydraulic cylinder 38 results in an increased cutting torque for all the blade positions (12 and 14) and also increases the open/closed cycle time for the shear 10. The size of the hydraulic cylinder 38 is effectively determined by the size of the shear 10 and the operating conditions desired.

In addition to the lengths of the linkages 24 and 28 and the length of the respective lever arms 180 and 182, the value of the angles θ between the respective linkages 24 and 28 and the longitudinal axis of the hydraulic cylinder 38, and an angle φ between the lever arm 180 and 182 and the longitudinal axis of the hydraulic cylinder 38 will depend on the initial distance between the pivot pin 34 and the main pin 16 in the fully open position. To allow for the needed pin diameters, required bushings and the like, the initial values of these angles should be at least 20 degrees. Due to the nature of the force transmission at pivot pin 34 and slide member 32, the final value of these angles will be less than 90 degrees and should be approximately 80 degrees.

The initial distance between pivot pin 34 and main pin 16 is limited by two physical limitations. First, the

distance must be less than the sum of the lengths of the respective lever arm 180 and 182 and linkage 24 or 28 by enough to allow the angles θ and φ discussed above to be at least about 20 degrees in the open position. Second, this distance must be large enough so that the pivot pin 34 will not run into the main pin 16 at the closed position. Decreasing the length of this initial distance decreases the cutting torque at all positions.

Another issue to review is the total jaw rotation angle. Increasing the size of the initial jaw opening increases the angular rotation necessary to go from the open position to the closed position. However, increasing this rotational angle also has an effect on the cutting torque curve. Increasing the total rotation angle causes an increase in the cutting torque when the jaws are almost fully open and a decrease in the cutting torque when in the fully closed position. Balancing all of the above considerations in the design of the shear 10 of Fig. 1 results in the shear opening, jaw depth, lever arm and linkage length being all substantially the same dimensional length. This ratio works for shears of all sizes such that the specific value of this dimensional length will depend upon the size of the shear desired. This relationship between the linkage length and the lever arm may also be maintained for the various tools illustrated in Figs. 12-23. The other relationships may be altered due to jaw structure changes.

Another important aspect of the present invention is the jaw structure of shear 10. The cutting edge of the first blade 12 is formed of a plurality of removable cutting inserts 190 removably attached to the first blade 12 by bolts or the like as well-known in the art. These inserts 190 may be indexible, meaning that the inserts 190 may be removed and rotated to provide new cutting edges as one cutting edge is worn. The first blade 12 includes a piercing tip 192 at a distal end of the first blade 12. The piercing tip 192 is also a removable cutting insert. However, the piercing tip

192 is intended to primarily make a cut transverse to the cut supplied by the cutting inserts 190. Specifically, the primary cut of the piercing tip 192 would be extending into and out of the illustration in Fig. 1. Additionally, the cutting inserts 190 along the first blade 12 are positioned in a hook shape to provide a first cutting portion 194 and a longer second cutting portion 196 positioned between the first cutting position 194 and the piercing tip 192. The shear 10 is designed so that the first cutting portion 194 is significantly less than, and preferably approximately one-half of, the length of the second cutting portion 196. The second blade 14 includes a plurality of cutting inserts 190 which are positioned in shearing relation with the cutting inserts 190 and piercing tip 192 to provide the shearing action for the shear 10. The second blade 14 provides a slot for the first blade 12 to extend through during the shearing action with the slot helping to maintain the cutting inserts 190 in shearing relation. The jaw design of the first blade 12 and second blade 14 in the shear 10 is constructed to help move material to be severed to the throat area adjacent the main pin 16 where the cutting forces are the highest. Having the piercing tip 192 sever the work piece in a direction transverse to the cutting of the first cutting portion 194 and second cutting portion 196 will help draw the material back to the throat. Additionally, the hook shape, i.e., the angle, between the first cutting portion 194 and the second cutting portion 196 will also serve to pull the material back to the throat area. Finally, the provision of the first cutting portion 194 having a dimension significantly less than the second cutting portion 196, will further assure that the material is pulled closer to the throat for cutting. This is believed to provide a significant improvement over the jaw designs of existing shears with plural movable blades and compliments the power curve associated with the shear design to magnify the effective shearing force. It is also within the scope of the present invention that different

shapes for the piercing tip 192 may be utilized for different types of material. Specifically, a piercing tip having a sharper or shallower angle when viewed from the side may be more or less appropriate for distinct types of work pieces.

Fig. 5 additionally illustrates that the sides 19 of the universal body 18 are pivoted to the yoke 21 through side pivots 78. This allows for easy replacement of the first and second blades 12 and 14 with the associated linkages 24 and 28, if desired. The pivotable sides 19 of the universal body 18 can be secured together by bolts or other fastening members. A rectangular tie bar 79 is positioned between the pivotable sides 19 through which the securing bolts extend. The tie bar 79 helps to maintain structural integrity of the universal body 18.

Figs. 28-30 illustrate a shear 10 similar to shear 10 of Fig. 1, except that the quick change feature is modified to utilize the pivoting sides 19 of the universal body 18. Specifically, the bridge housing 48 has been omitted and the main pin 16 is used to couple the jaw set directly to the universal body 18. Fig. 29 illustrates bolts 198 which can be used for holding the sides 19 of the universal body 18 together.

Figs. 31-34 schematically illustrate the process of disassembling the jaw structure and inserting a new jaw structure at the main pin 16 for the quick change device shown in Figs. 28-30. As best shown in these figures, this design essentially keeps the structure generally symmetrical about the center line thereby avoiding inappropriate torquing during use of the shear 10. It will be appreciated that bearing sleeves 202 may be positioned between appropriate elements and the main pin 16. Retaining members 204 may be secured for holding the assembly in place.

As illustrated in Fig. 32, by removing retaining bolts 206, a retaining cap 208, retaining clips 210 and an alignment sleeve 212 from attachment with the sides 19 of the universal body 18, the main pin 16 and associated assembly is

ready for removal. As shown in Fig. 33, once the retaining system has been disassembled, the sides 19 of the universal body 18 rotate outwardly to simplify the removal process.

It will be apparent that before the first and second blades 12 and 14 can be removed, the linkages 24 and 28 must be detached from either the first and second blades 12 and 14 or the slide member 32. In general, the pivot pins 26 and 30 are removed for disconnecting the linkages 24 and 28 from the respective blades 12 and 14. However, it is possible for the linkages 24 and 28 to remain with the blades 12 and 14 as a single tool unit. This may be important if different linkage lengths are desired for the next tool set.

Maintaining the first linkage 24 and the second linkage 28 with the first and second blades 12 and 14 requires the decoupling of the linkages 24 and 28 from the slide member 32, or alternatively, decoupling the slide member 32 from the piston rod 36. In this latter arrangement, the decoupling of the slide member 32 from the piston rod 36 can be by bolts, a pin type connection or other secure fastening which can be easily disassembled. A continuous sleeve 214, shown in Fig. 6, is positioned around pivot pin 34 which couples the linkages 24 and 28 to the slide member 32. The sleeve 214 provides that the linkages 24 and 28 will be held together in a single assembly around sleeve 214 following the removal of pivot pin 34. This structure allows the linkages 24 and 28 to be removed, if needed. The removal of the linkages may be desired so that the linkage lengths can be changed with the next tool set.

Regardless of how the linkages are decoupled, with the linkages 24 and 28 decoupled and the sides 19 of the universal body 18 rotated outward, the entire jaw structure comprising the blades 12 and 14, and linkages 24 and 28, if maintained with the blades 12 and 14, can be removed and a separate tool assembly installed (with new linkages 24 and 28 if these were removed). Following this assembly, the sides of the universal body 18 will be pivoted back together and

the retaining system attached around a new main pin 16 such as shown in Fig. 32. Bolts will reattach the sides 19 of the universal body 18 to complete the reassembly. As shown in Fig. 34, the new blades 12 and 14 have different retaining members and bearing sleeves associated with this particular tool unit. A particular bearing structure will be designed in accordance with the specific tool unit implemented.

Fig. 35 illustrates a shear 10 which incorporates a side access plate 222 for permitting access to the slide member 32 and the associated pivot pin 34. Specifically, the universal body 18 includes the access plates 222 secured thereto which can be removed to gain access to the guided slide member 32 within the universal body 18.

Fig. 36 illustrates a modified universal body 18 in which the bolts for attaching the pivotable sides 19 of the universal body 18 are replaced with a retaining connection 224.

Figs. 37 and 38 illustrate a modified universal body 18 in which the sides 19 of the universal body 18 are pivoted about side pivots 78 and are secured by independent retaining connections 224 to the universal body 18.

Figs. 39 and 40 illustrate a further modified universal body 18 in which the sides 19 of the universal body 18 are completely separable from the remaining portions of the universal body 18 and secured thereto by the attachment of the trunnion 40 and separate retaining connections 224.

Fig. 41 illustrates a modification of the shear 10 in which the slot 44 is replaced with a guide rod 230 upon which the slide member 32 slides. This modification also results in changing the attachment of the linkages 24 and 28 from a common position to separate offset positions by independent pins 232 and 234. This change also results in a change in the geometric relationship discussed above in which the offset created must be accounted for in the resulting shear. This offset provides a less desirable shear in terms of cutting characteristics.

Another aspect of the present invention is the details of the slide member 32 and the coupling to the piston rod 36 as shown in Figs. 4, 6 and 7. A sleeve 214 is specifically formed as a hardened steel member and is keyed to the pivot pin 34 through key 242 positioned behind a cover plate 244. Wear plates 246 are on the sides of the slide member 32 to be captured in the slot 44 against wear plates 248 in groove 44. The slide member 32 is connected through a pin 250 to a rod eye 252 of the piston rod 36. The pin 250 allows for rotation of the rod 36 about an axis which is 90 degrees from the axis of the trunnion 40. The sleeve 214 will maintain the linkages 24 and 28 together even following removal of the pin 34. Additionally, the replaceable sleeve 214 absorbs most of the transmitted shear load such that most of the wear will occur on the sleeve 214 and not the pin 34. Bushings 260 located at each linkage 24 and 28 will ensure proper alignment and eliminate linkage-to-linkage, or linkage-to-slide member, wear. Keying the pivot pin 34, sleeve 214 and slide member 32 together by key 242 will prevent rotation of the pin 34 or sleeve 214 and eliminate the likelihood of flat spots developing on either structure. The pinning of the rod eye 252 to the slide member 32 allows for misalignment in relation to the hydraulic cylinder 38 and the slide member 32 which, in conjunction with the trunnion 40, will help to prolong the seal life of the hydraulic cylinder 38. Finally, it is anticipated that the wear plates 246 will be made of high wear brass with impregnated graphite, thus eliminating the need for lubrication of these components. These components will serve two functions. First, they prevent the frictional wear between the slide member 32 and the mating part in the slot 44. Second, the wear plates 246 serve to keep exact linear motion of the slide member 32 in the event of unperceived side loading, thereby maintaining the highest possible cylinder force in operation.

Fig. 42 is a schematic illustration of a jaw and linkage design also including an offset similar to that shown in Fig. 41. However, the embodiment illustrated in Fig. 42 is considered a "negative" offset due to the crossing of the respective linkages 24 and 28. The negative offset represented by the embodiment illustrated in Fig. 42 may have a beneficial effect in the theoretical operation of the shear, however, appropriate design of the crossing or linkage arrangement increases the complexity of the device.

Fig. 43 illustrates an embodiment of the shear 10 in which a rotatable connection 280 is provided between the piston rod 36 and the slide member 32. The provision of a rotational coupling 280 means that the trunnion 40 can be moved back and utilized for attaching the hydraulic cylinder 38 to the bearing housing 20 rather than attaching it to the yoke 21. Furthermore, since the hydraulic cylinder 38 will not rotate when the universal body 18 rotates, a simple, more conventional hydraulic cylinder 38 can be utilized in this embodiment.

Figs. 44-46 illustrate a shear 300 of a distinct type different from the shear 10. Specifically, the shear 300 includes a first pivotable blade 302 pivotally attached to a fixed blade 304 through hub 305. The shear 300 is similar to the shear 10 in that a linkage 306 couples the blade 302 to a slide member 308 which is received in a guiding slot 310. The shear 300 additionally includes piston rod 36, hydraulic cylinder 38, trunnion 40 and the bearing housing 20 similar to shear 10 described above.

Figs. 47 and 48 illustrate a modification of shear 300 in which the slide member 308 and slot 310 are replaced with a separate linkage 312 to the fixed blade 304 and the rod eye 252 of piston rod 36. The linkage 306 is also attached to the rod eye 252 and linkage 312. In this embodiment, the guiding of the piston is non-linear and travels through an arc defined by the linkage 312. The

hydraulic cylinder 38 will also pivot about trunnion 40 throughout the movement of the linkage 312.

Figs. 49-53 illustrate a shear 10 which details a universal body 18 incorporating a simple four pin connection between the rotary coupling 23 and an adapter 20a. The adapter 20a essentially replaces the bearing housing 20 of earlier embodiments. As shown in Figs. 50 and 51 the rotary coupling 23 includes parallel connecting plates 320 which receive four connector pin assemblies 330. The connector pin assemblies 330 provide a simple connection between the rotary coupling 23 and the adapter 20a. A connector pin assembly 330 is shown in detail in Fig. 51. Each connector pin assembly 330 includes a connecting pin 332 received in and extending between a pair of adjacent connector plates 320 within bushings 334 and 336. The bushing 336 and the connecting pin 332 receive a locking bolt 338 secured by nut 340 to hold the connector pin assembly 330 in position. As shown in Figs. 52 and 53, the adapter 20a includes a pair of parallel side plates having receiving apertures 342 that are received between pairs of adjacent connecting plates 320 to receive the connecting pin 332 therethrough. This provides a simple, easily released connection between the rotary coupling 23 and the adapter 20a.

Fig. 54 illustrates a shear 10' which details a universal body 18' incorporating a simple four pin connection between the yoke 21' and the adapter 20a. The four pin connection is similar to the shear of Fig. 49 except without a rotary coupling in the universal body. The parallel connecting plates extend from the yoke 21' rather than the rotary coupling.

Fig. 55 illustrates a shear 10 incorporating a simple four pin connection between the rotary coupling 23 and the adapter 20a as shown in Fig. 49. The shear 10 of Fig. 55 is designed as a stick mounted type shear, also referred to as a third member mount type adapter. Essentially, the adapter 20a is configured for this type of arrangement. Fig.

55 further illustrates the versatility of the shears of the present invention.

It will be apparent to those of ordinary skill in the art that various modifications may be made to the present invention without departing from the spirit and scope thereof. The described embodiments are intended merely to be illustrative of the concepts of the present invention and not restrictive thereof.

WHAT IS CLAIMED IS:

1. A demolition tool comprising:

a universal body adapted to be attached to demolition equipment, the universal body including a guide slot extending longitudinally along the universal body;

a pair of pivotable blades pivotably attached together and removably attached to the universal body;

at least one linkage attached to each blade;

a slide member received within the guide slot, with each linkage attached to the slide member; and

a piston cylinder arrangement attached to the universal body and coupled to the slide member for moving the slide member and the blades.

2. The demolition tool according to claim 1 further including a common pivot pin connecting each linkage to the slide member.

3. The demolition tool according to claim 2 wherein the common pivot pin connecting each linkage to the slide member is aligned with a piston rod of the piston cylinder arrangement.

4. The demolition tool according to claim 1 further including a quick change assembly coupling the pair of pivotable blades to the universal body.

5. The demolition tool according to claim 4 wherein the quick change assembly includes a main pin pivotably connecting the blades and a bridge housing surrounding the main pin and detachably connected to the universal body.

6. The demolition tool according to claim 1 wherein the piston cylinder is a combined hydraulic cylinder and rotary joint.

7. The demolition tool according to claim 6 wherein the combined hydraulic cylinder and rotary joint includes a rotatable cylinder housing, a rotatable cylinder extension extending from the cylinder housing, and a stationary housing surrounding the cylinder extension.

8. The demolition tool according to claim 1 wherein each blade includes a plurality of removable inserts.

9. The demolition tool according to claim 1 further including a rotary coupling in the universal body providing for 360 degree rotation of the pair of blades.

10. A universal body assembly for a plurality of demolition tools, the universal body assembly comprising:

a bearing housing for mounting the universal body assembly to demolition equipment;

a yoke positioned forward of the bearing housing;

a pair of sides extending from the yoke, the sides defining a guide slot extending longitudinally along the universal body assembly, the sides adapted to removably receive one of a plurality of distinct demolition tools; and

a slide member positioned within the guide slot movable along the length of the guide slot.

11. The universal body of claim 10 wherein the sides are pivotably attached to the yoke.

12. The universal body of claim 11 wherein the pivotable sides are moved to provide access to the slide member, and further including a tie bar for coupling the pivotable sides together wherein fasteners extend through the tie bar.

13. The universal body of claim 10 wherein the sides include removable access plates which provide access to the slide member.

14. The universal body of claim 10 further including a piston cylinder assembly coupled to said slide member for moving the slide member.

15. The universal body of claim 14 further including a trunnion pivotably attaching the piston cylinder assembly to the yoke

16. The universal body of claim 15 further including a pivot pin connecting the piston rod of the piston cylinder assembly to the slide member which has an axis substantially perpendicular to the axis of the trunnion.

17. The universal body of claim 10 further including a rotary coupling between the bearing housing and the yoke.

18. The universal body of claim 17 further including a piston cylinder assembly coupled to said slide member for moving the slide member, wherein a cylinder of the piston cylinder assembly is rotatable with the yoke.

19. The universal body of claim 10 further including a quick change assembly on the sides for quickly attaching tools.

20. A multiple tool attachment system adapted to be attached to demolition equipment, the system comprising:

a universal body attachable with the demolition equipment;

a hydraulic cylinder attached to the universal body;

a pair of linkages adapted to be coupled with the hydraulic cylinder; and

a plurality of demolition tool units each selectively, removably attachable to the universal body and the hydraulic cylinder, each tool unit including a pair of pivotable blades adapted to be pivotally connected to the universal body and to the pair of linkages.

21. The multiple tool attachment system of claim 20 wherein at least one of the plurality of demolition tool units is a cutting shear.

22. The multiple tool attachment system of claim 21 wherein at least one of the plurality of demolition tool units is a concrete crushing tool.

23. The multiple tool attachment system of claim 22 wherein at least one of the plurality of demolition tool units is a grapple.

24. The multiple tool attachment system of claim 20 wherein at least one of the plurality of demolition tool units has each blade including a plurality of removable inserts.

25. The multiple tool attachment system of claim 20 further including a quick change assembly coupling the pair of pivotable blades of each demolition tool unit to the universal body.

26. The multiple tool attachment system of claim 25 wherein the quick change assembly includes a main pin pivotably connecting the blades of each demolition tool unit

and a bridge housing surrounding the main pin and detachably connected to the universal body.

27. The multiple tool attachment system of claim 26 wherein the quick change assembly further includes keeper pins adapted to be received within aligned apertures in the bridge housing and the universal body.

28. The multiple tool attachment system of claim 20 wherein the pair of linkages are selectively removable from the hydraulic cylinder and the universal body to accommodate further demolition tool units having distinct linkages.

29. The multiple tool attachment system of claim 28 wherein the pair of linkages are coupled to the hydraulic cylinder through a common pivot pin within a sleeve, wherein the sleeve can hold the linkages together after detachment from the hydraulic cylinder.

30. A heavy-duty shear comprising:

a body attachable to demolition equipment;

at least one hydraulic cylinder on said body; and

a pair of pivotable blades attached at a common pivot point to the body and coupled to at least one cylinder for movement of the blades in a shearing relation, at least one of the movable blades includes,

i) a first cutting portion adjacent the pivot point of the blade,

ii) a replaceable piercing tip at a distal end of the blade, and

iii) a second cutting portion between the piercing tip and the first cutting portion wherein the length of the first cutting portion is less than the length of the second cutting portion.

31. The heavy duty shear of claim 30 wherein the body includes a guide slot, and further including a linkage attached to each blade, and a slide member received within the guide slot coupled to the cylinder.

32. The heavy duty shear of claim 31 further including a common pivot pin connecting each linkage to the slide member.

33. The heavy duty shear of claim 32 wherein the common pivot pin connecting each linkage to the slide member is aligned with a piston rod of the cylinder.

34. The heavy duty shear of claim 30 further including a quick change assembly coupling the pair of pivotable blades to the body.

35. The heavy duty shear of claim 34 wherein the quick change assembly includes a main pin pivotably connecting the blades at the common pivot point and a bridge housing surrounding the main pin and detachably connected to the universal body.

36. The heavy duty shear of claim 30 wherein the body includes a bearing housing for mounting the shear to demolition equipment, a yoke positioned forwardly of the bearing housing, a pair of sides extending from the yoke, the sides defining a guide slot extending longitudinally along the body, and slide member positioned within the guide slot movable along the length of the guide slot.

37. The heavy duty shear of claim 36 wherein the sides are pivotably attached to the yoke and wherein the pivotable sides are moved to provide access to the slide member.

38. The heavy duty shear of claim 36 wherein the hydraulic cylinder is coupled to the slide member for moving the slide member and further including a trunnion pivotably attaching the piston cylinder assembly to the yoke.

39. The heavy duty shear of claim 38 further including a pivot pin connecting the piston rod of the piston cylinder assembly to the slide member which has an axis substantially perpendicular to the axis of the trunnion, and a rotary coupling between the bearing housing and the yoke.

40. A demolition tool comprising:

a bearing housing attachable to demolition equipment;

a rotational coupling secured to the bearing housing;

a yoke attached to the rotational coupling and rotatable relative to the bearing housing through the rotational coupling;

side members attached to the yoke;

at least one demolition tool attachable to the side members; and

a hydraulic cylinder attached to the yoke and the bearing housing for moving the demolition tool, wherein a portion of the cylinder attached to the yoke is rotatable relative to the portion of the cylinder coupled to the bearing housing.

41. The demolition tool of claim 40 wherein the hydraulic cylinder includes a cylinder housing and a cylinder extension extending from the cylinder housing which rotate relative to the bearing housing, and a stationary housing surrounding the cylinder extension which is attached to the bearing housing.

42. The demolition tool of claim 41 further including hydraulic lines within the cylinder housing, cylinder extension and bearing housing, wherein the cylinder housing separates the cylinder bore from the cylinder extension.

43. The demolition tool of claim 41 further including a trunnion pivotably mounting the cylinder housing to the yoke.

44. The demolition tool of claim 43 further including a pivot pin connecting a piston rod of the hydraulic cylinder to a slide member moved by the hydraulic cylinder, wherein the pivot pin has an axis substantially perpendicular to the axis of the trunnion.

45. The demolition tool of claim 40 further including a guide member guiding the movement of a piston rod of the hydraulic cylinder.

46. The demolition tool of claim 45 wherein the guide member is a linkage pivotably attached to the side members and to a piston rod of the hydraulic cylinder.

47. The demolition tool of claim 45 wherein the guide member is a guide rod, and further including a slide member connected to a piston rod of the hydraulic cylinder and slidably received on the guide rod.

48. The demolition tool of claim 45 wherein the guide member is a guide slot formed in the side members, and further including a slide member connected to a piston rod of the hydraulic cylinder and slidably received in the guide slot.

49. The demolition tool of claim 40 wherein the side members are separable from the yoke.

50. A method of designing and forming a demolition tool unit having a pair of moveable blades forming a jaw structure, a linkage connected to each blade, and a common hydraulic cylinder attached to each linkage for moving the blades, the method comprising the steps of:

A) developing a general jaw geometry which defines main geometric parameters of the general jaw structure of the demolition tool unit;

B) analyzing the jaw geometry to determine at least the working torque of general jaw structure throughout the range of motion of the blades;

C) determining the relative value of main geometric parameters of the general jaw structure which at least optimizes the working torque characteristics throughout the range of motion of the blades; and

D) forming a demolition tool unit having the main geometric parameters determined in step C).

51. The method of claim 50 wherein the main geometric parameters of the general jaw structure which are analyzed include a lever arm of each blade and a length of each linkage.

52. The method of claim 51 wherein the main geometric parameters of the general jaw structure which are analyzed further include a jaw depth of the blades, a maximum opening of the blades, a relative angular orientation of the

linkages to the hydraulic cylinder and a relative angular orientation of the lever arm to the hydraulic cylinder.

53. The method of claim 52 further including the step of analyzing the cycle time of the general jaw structure.

54. The method of claim 50 wherein the maximum working torque is set near the closed position of the blades.

55. The method of claim 50 wherein the working torque increases throughout the blade movement.

56. The method of claim 50 wherein the step of determining the relative value of main geometric parameters includes varying the lengths of the linkages and of the lever arms.

57. The method of claim 50 wherein the step of determining the relative value of main geometric parameters includes varying the distance between the end of each linkage and the centerline of the hydraulic cylinder.

58. A demolition tool comprising:

a universal body adapted to be attached to demolition equipment;

at least one movable blade pivotably attached to the universal body; and

one linkage extending from each movable blade to a hydraulic piston, wherein a length of each linkage is substantially equal to a length from a position where the linkage is connected to the blade to a pivot point of the blade about the universal body.

59. The demolition tool of claim 58 wherein a jaw depth of each blade is substantially equal the length of each linkage.

60. The demolition tool of claim 58 further including an offset between each the connection of each linkage to the hydraulic piston and the axis of the piston.

61. The demolition tool of claim 58 wherein each linkage is connected to the hydraulic piston at a common pivot pin.

62. The demolition tool of claim 61 wherein the common pivot pin is aligned with the axis of the piston.

63. A demolition tool adapted to be attached to demolition equipment, the tool comprising:

a universal body adapted to be attached to the demolition equipment;

a pair of pivotable blades pivotably attached to the universal body;

at least one linkage attached to each blade;

a slide member received within the body, with each linkage attached to the slide member; and

a piston cylinder arrangement attached to the universal body and coupled to the slide member for moving the slide member and the blades, wherein the force generated by the blades during movement of the blades peaks near the closing of the blades.

64. A multiple tool attachment system for selectively attaching one of a plurality of tool sets to demolition equipment, the system comprising:

a universal body having a guide slot therein;

a slide member slidably received in the guide slot;

a hydraulic cylinder attached to the universal

body and coupled to the slide member for moving the slide member along the guide slot; and

a quick release member for selectively attaching tool sets, wherein the quick change assembly includes a main pin pivotably connecting moveable blades of each demolition tool set and a bridge housing surrounding the main pin and detachably connected to the universal body.

65. The multiple tool attachment system of claim 64 wherein the quick change assembly further includes keeper pins adapted to be received within aligned apertures in the bridge housing and the universal body.

66. The multiple tool attachment system of claim 64 wherein the universal body includes a bearing housing for mounting the system to demolition equipment, a yoke positioned forward of the bearing housing, and a pair of sides extending from the yoke, the sides defining the guide slot extending longitudinally along the body.

67. The multiple tool attachment system of claim 66 wherein the sides are pivotably attached to the yoke, and wherein the sides are moveable to provide access to the slide member.

68. The multiple tool attachment system of claim 66 wherein the sides are removably attached to the yoke, and wherein the sides are removable to provide access to the slide member.

69. A multiple tool attachment system for selectively attaching one of a plurality of tool sets to demolition equipment, the system comprising:

a universal body having a pair of pivotable sides with a guide slot formed in each pivotable side;

a slide member slidably received in the guide slots in the sides; and

a hydraulic cylinder attached to the universal body and coupled to the slide member for moving the slide member along the guide slot.

70. A multiple tool attachment system for selectively attaching one of a plurality of tool sets to demolition equipment, the system comprising:

a universal body having a guide slot therein;

a slide member slidably received in the guide slot;

a hydraulic cylinder attached to the universal body and coupled to the slide member for moving the slide member along the guide slot; and

a pair of linkages extending from a common point on said slide and adapted to be selectively attached to individual movable jaws of individual tool sets.

71. A tool set for coupling to a body having a hydraulic cylinder for powering the tool set, the tool set comprising:

a pair of movable blades pivoted together;

a common pivot pin connecting the blades together; and

a bridge housing coupled to the pivot pin, the bridge housing providing a quick release system for attaching the tool set to the body.

72. A heavy-duty shear comprising:

a body attachable to demolition equipment;

at least one hydraulic cylinder on said body; and

a pair of pivotable blades attached at a common pivot point to the body and coupled to at least one cylinder for movement of the blades in a shearing relation, one movable blade having a slot receiving the other movable blade, wherein one of the movable blades includes,

i) a first cutting portion adjacent the pivot point of the blade,

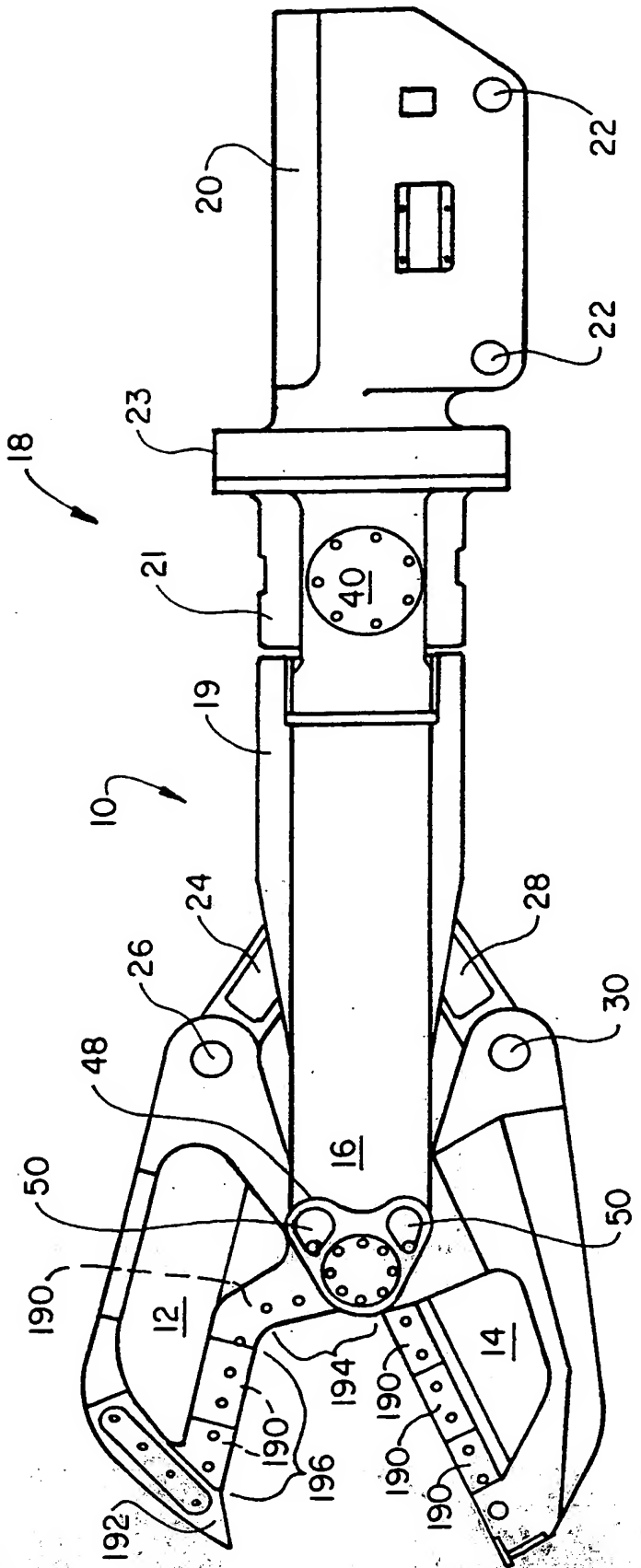
ii) a replaceable piercing tip at a distal end of the blade, and

iii) a second cutting portion between the piercing tip and the first cutting portion wherein a substantially continuous cutting line is provided from the piercing tip to the end of the first cutting portion adjacent the first cutting portion.

73. The heavy-duty shear of claim 72 wherein the body includes a guide slot, and further including a linkage attached to each blade, and a slide member received within the guide slot coupled to the cylinder.

74. The heavy-duty shear of claim 72 wherein the first cutting portion and the second cutting portion include a plurality of replaceable inserts.

75. The heavy-duty shear of claim 74 wherein the replaceable inserts are indexable, whereby the inserts each include a plurality of cutting edges which can selectively be positioned into an operative position.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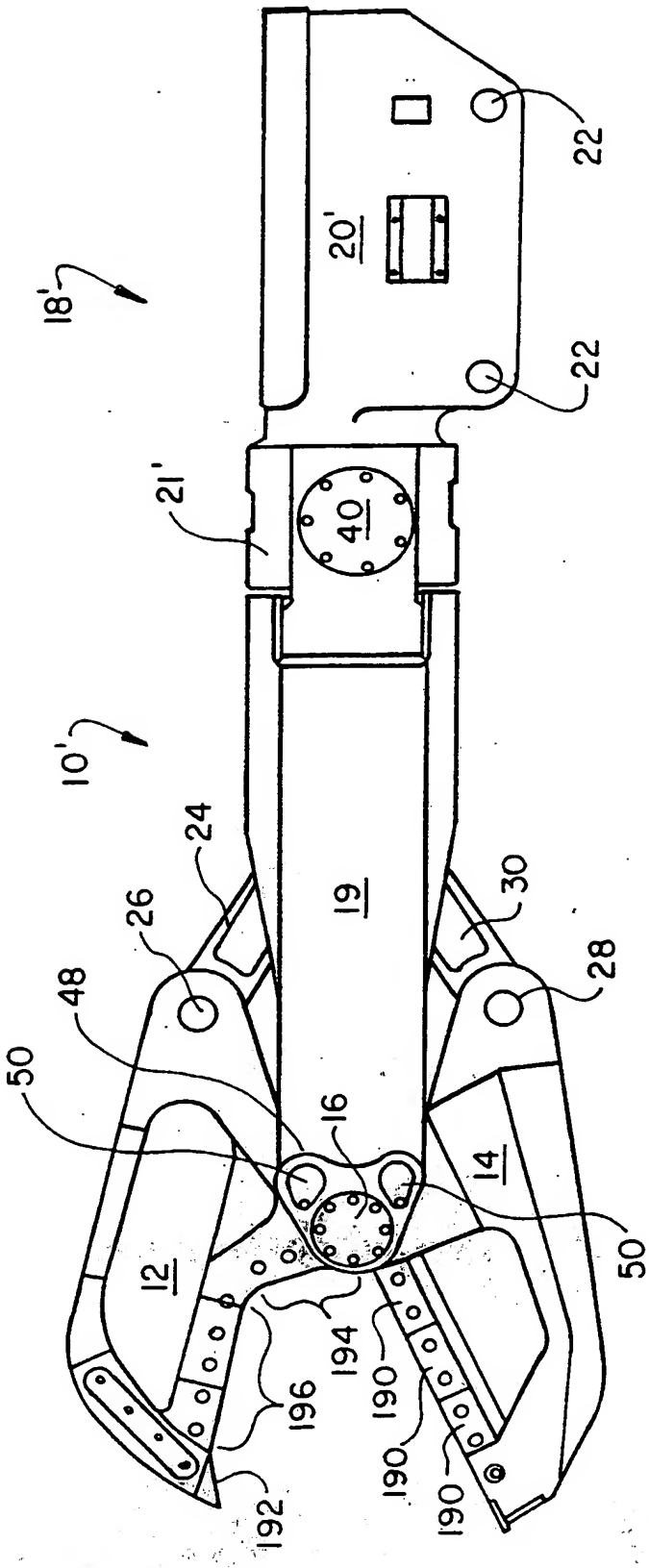
192

FIG. 1


18'
20'
22
22
21'
40
10'
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14
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194
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192

FIG. 2

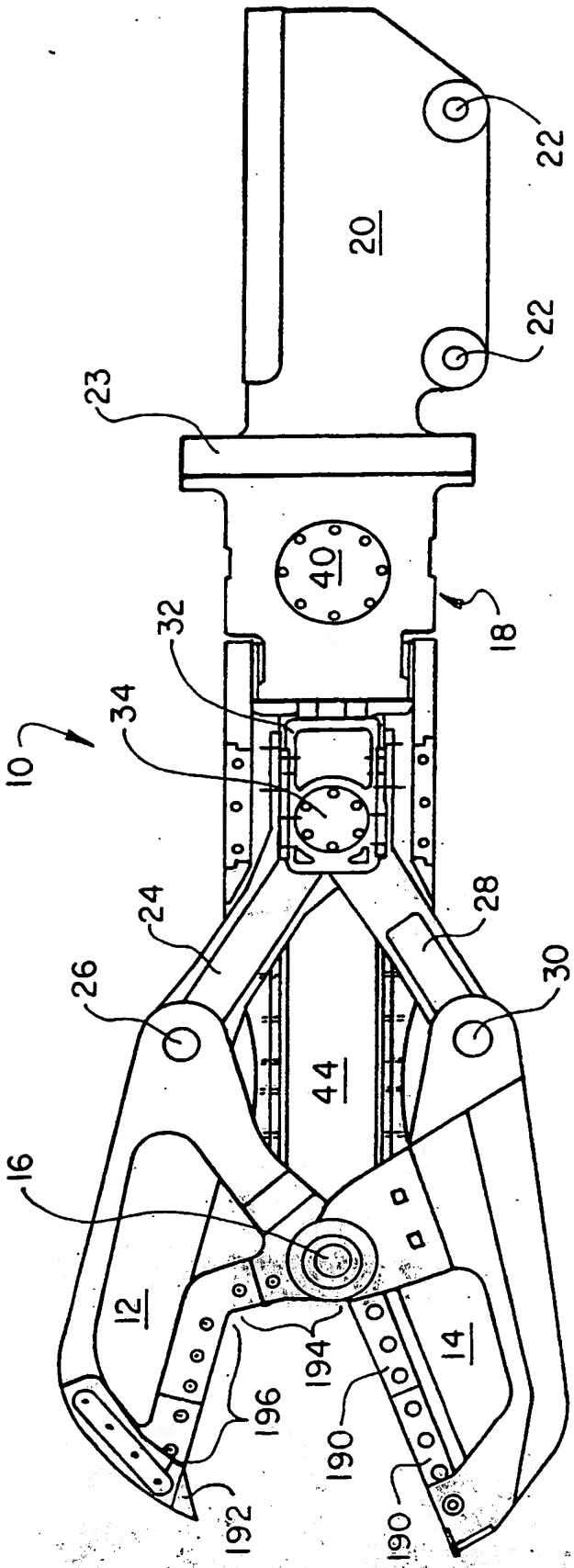

FIG. 3

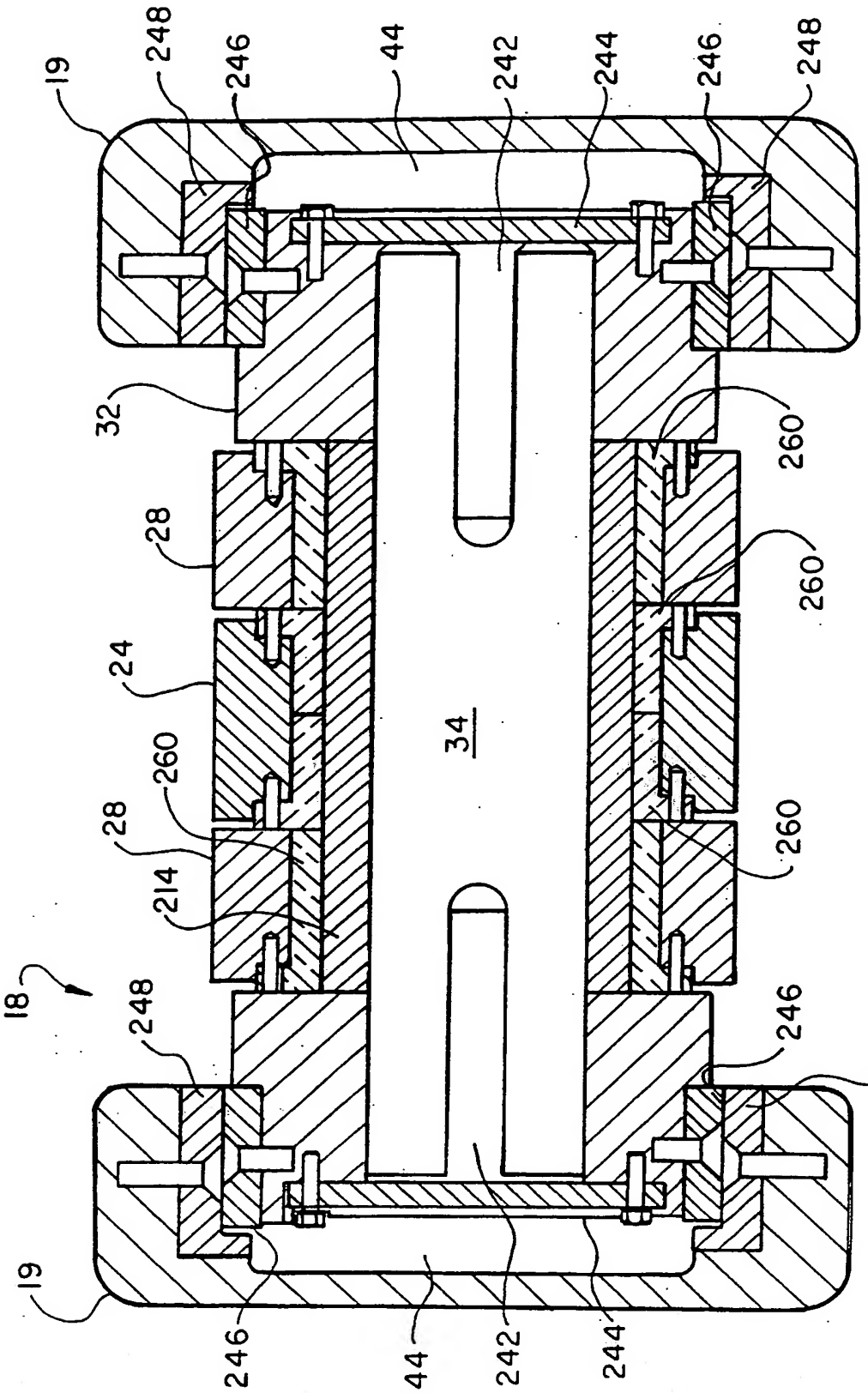
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FIG. 4

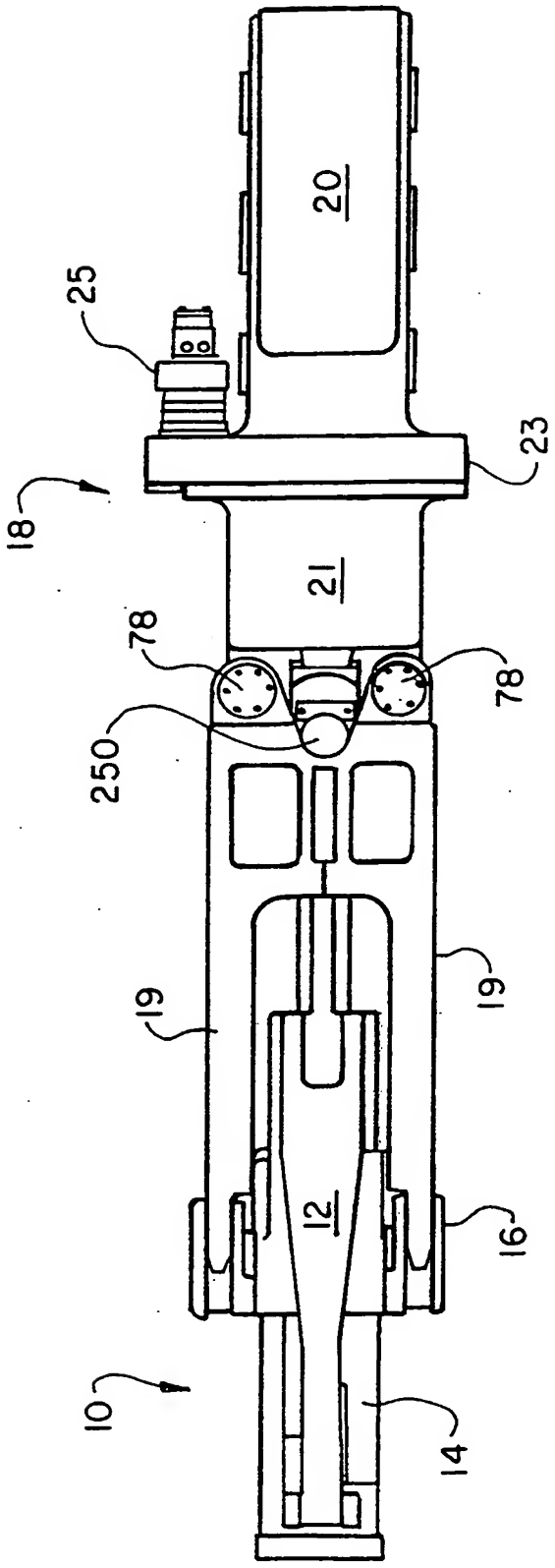
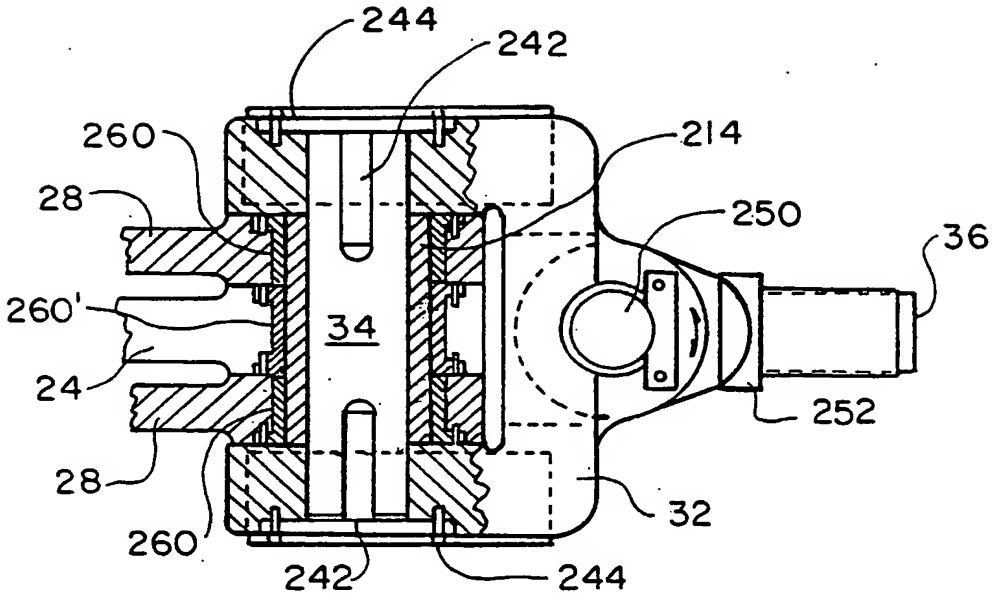


FIG. 5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36
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32
260
242
244

FIG. 6

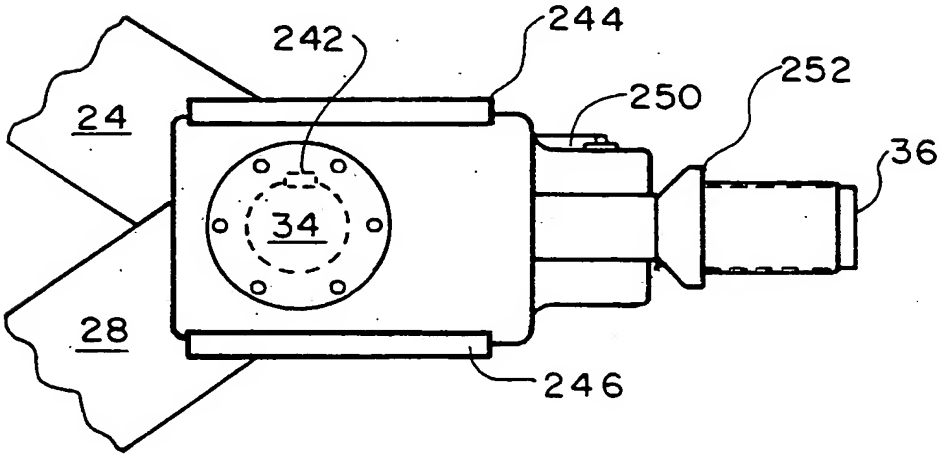
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FIG. 7

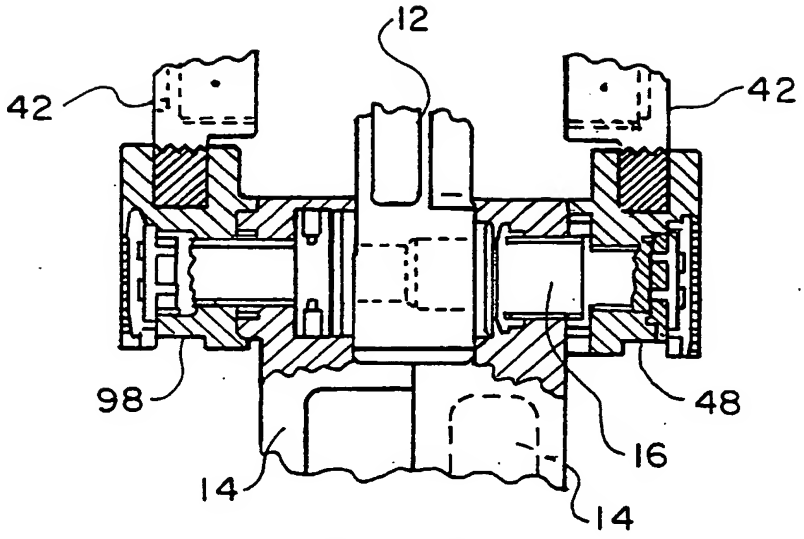


FIG. 8

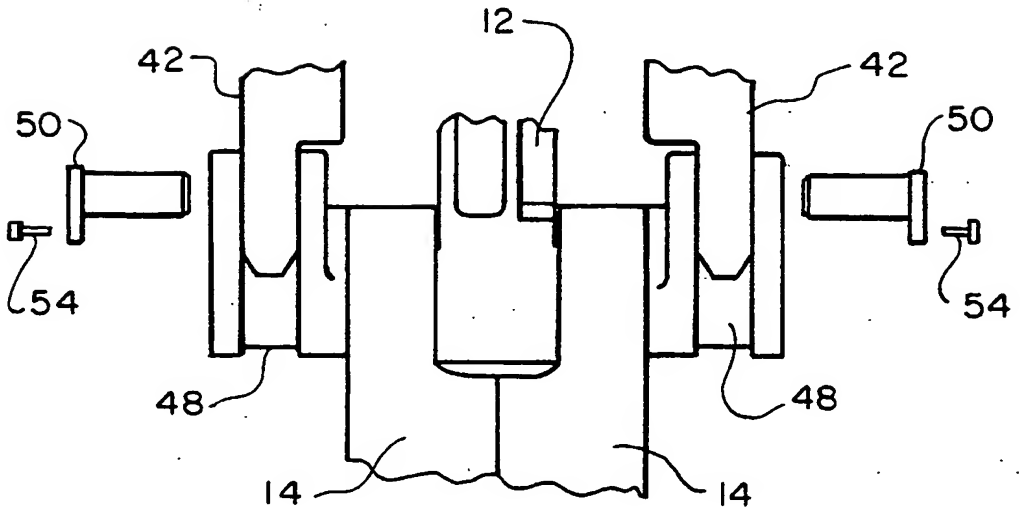


FIG. 9

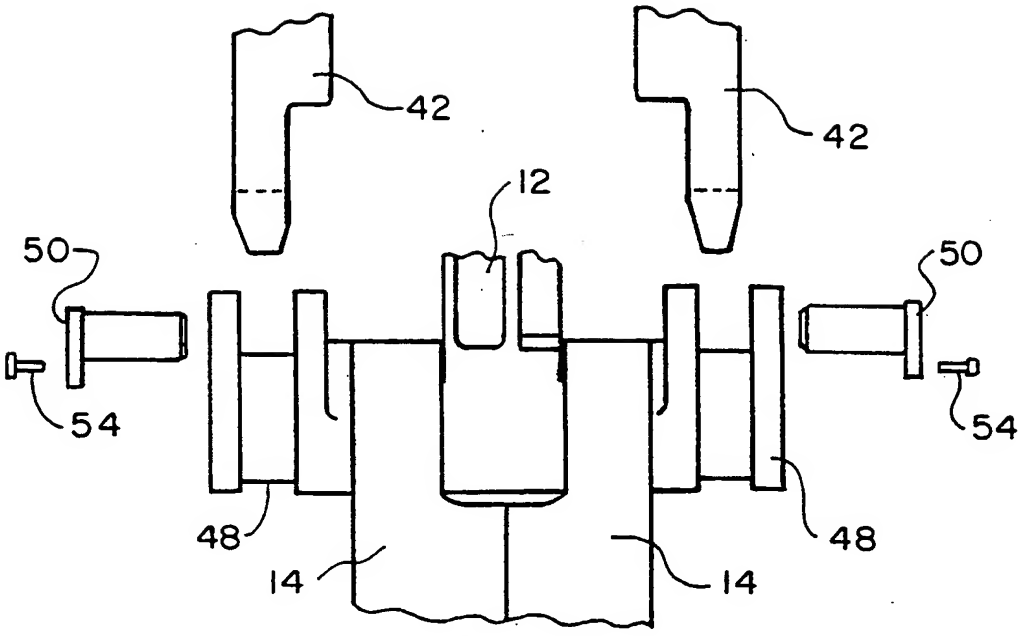


FIG. 10

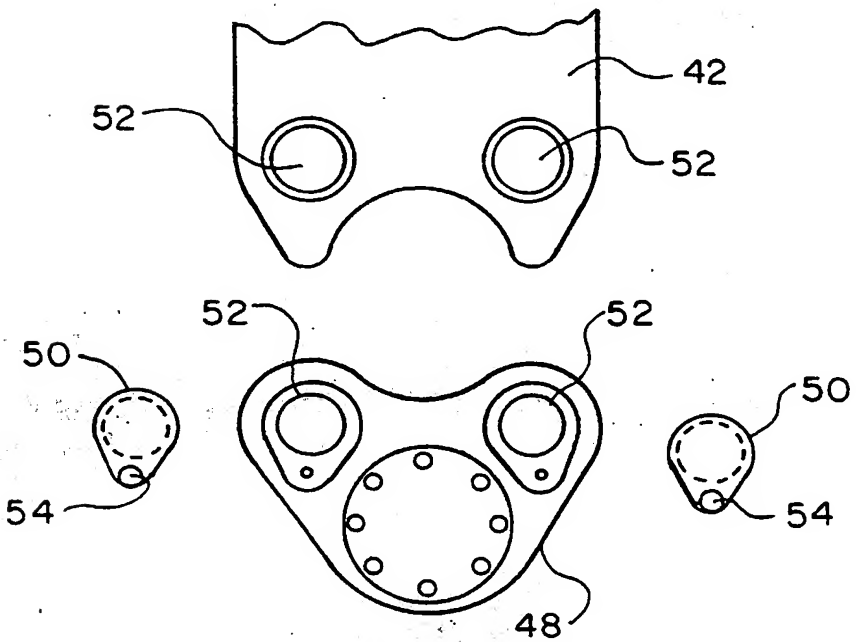


FIG. 11a

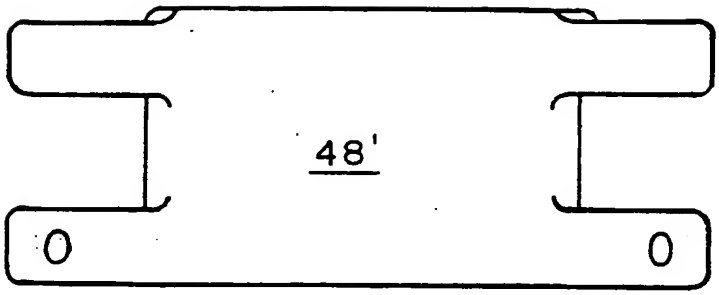


FIG. 11b

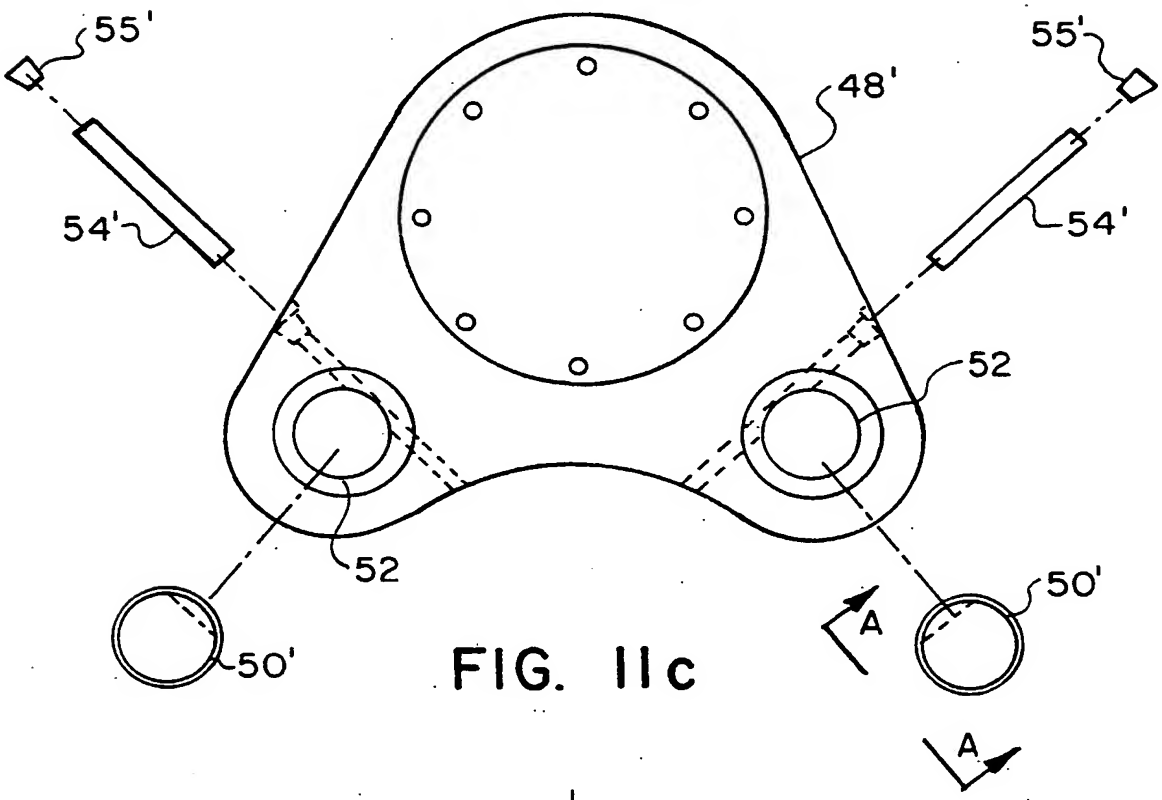


FIG. 11c

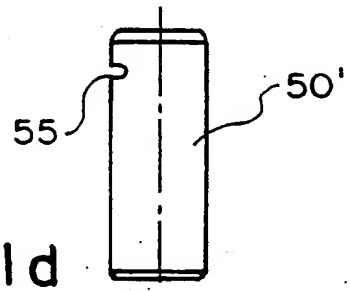


FIG. 11d

VIEW A-A

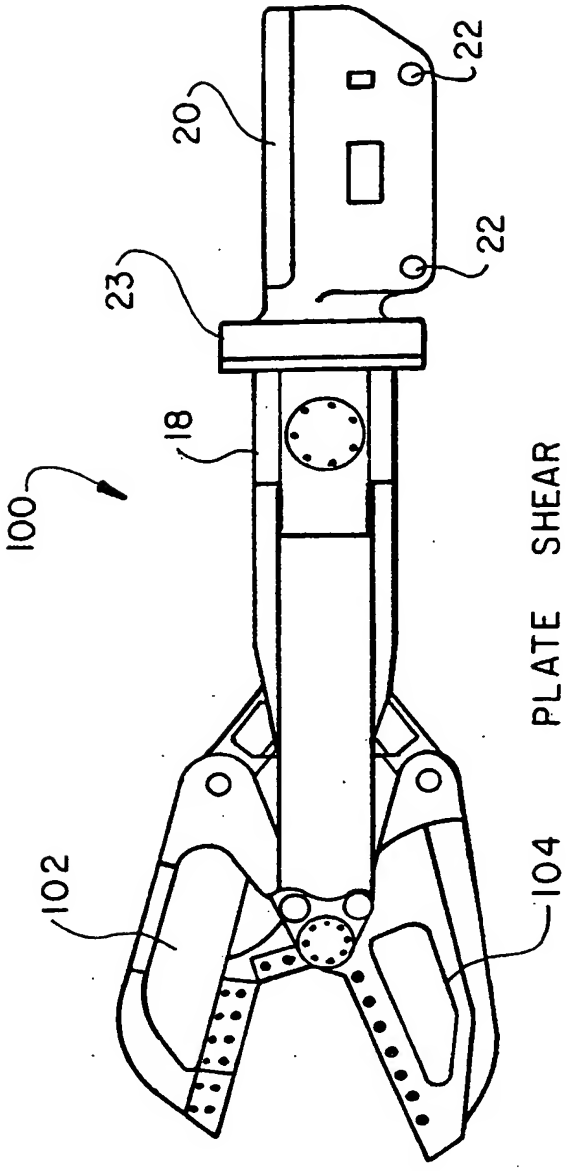


FIG. 12 PLATE SHEAR

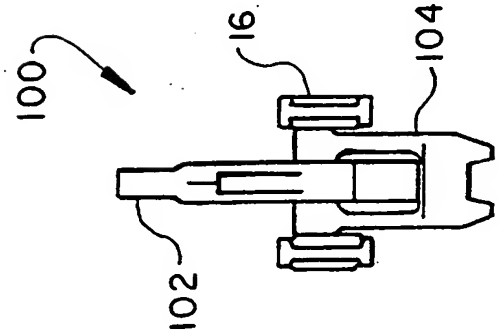
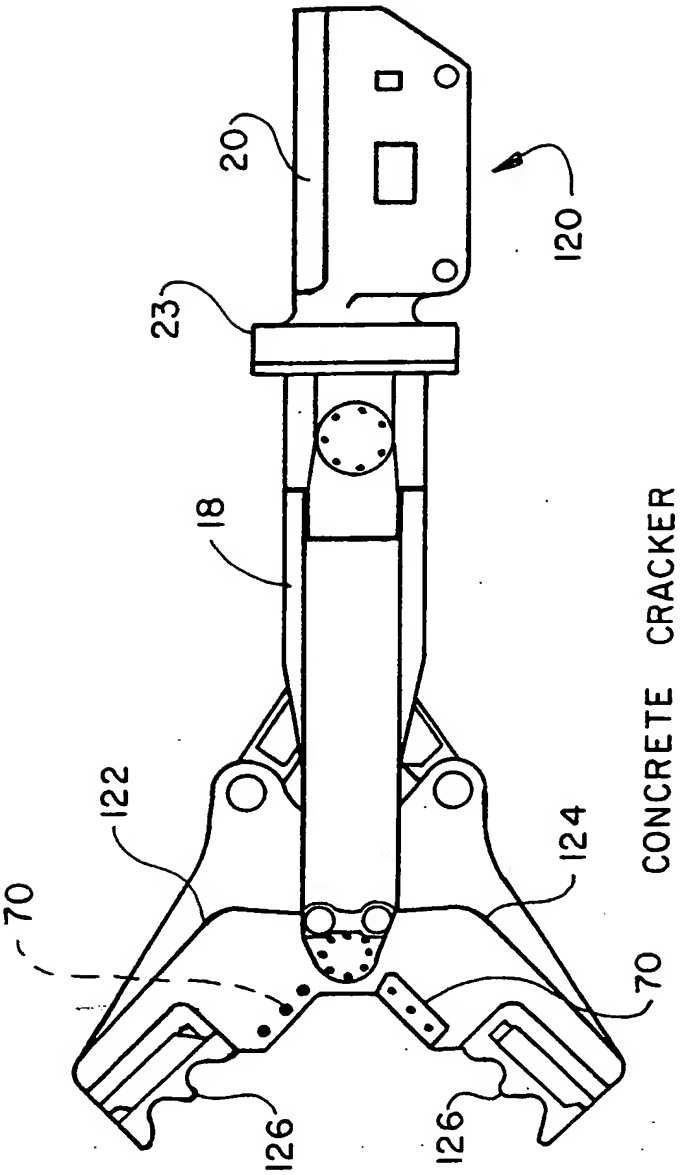


FIG. 13



CONCRETE CRACKER

FIG. 14

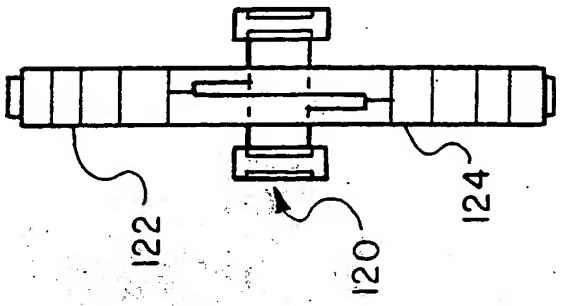
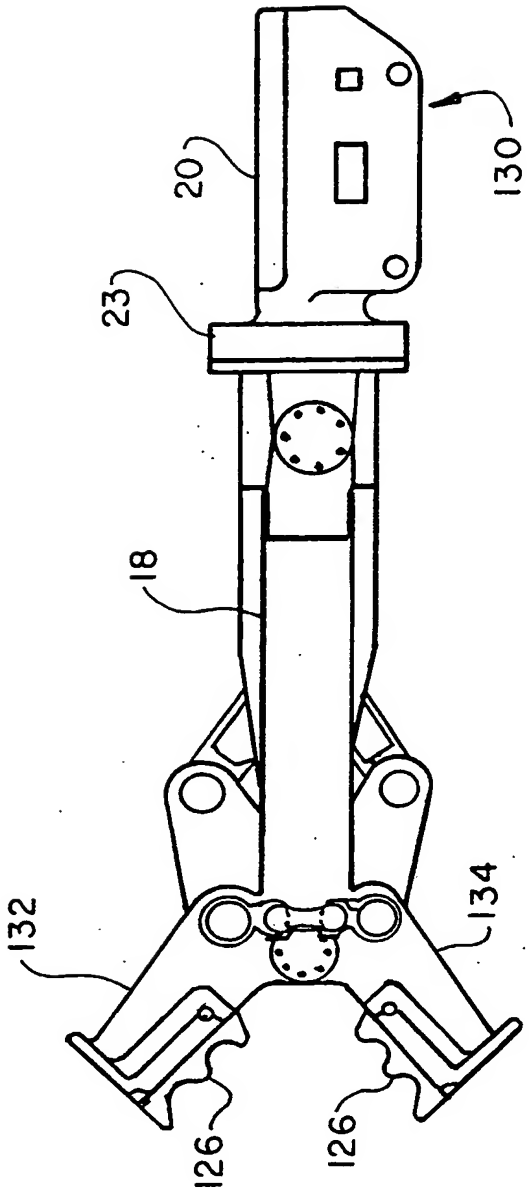


FIG. 15



CONCRETE PULVERIZER

FIG. 16

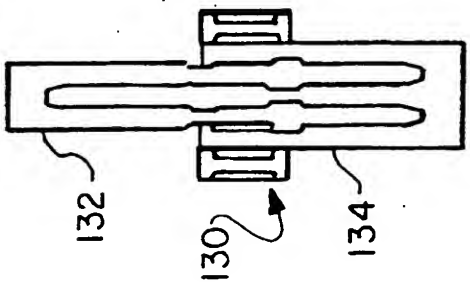


FIG. 17

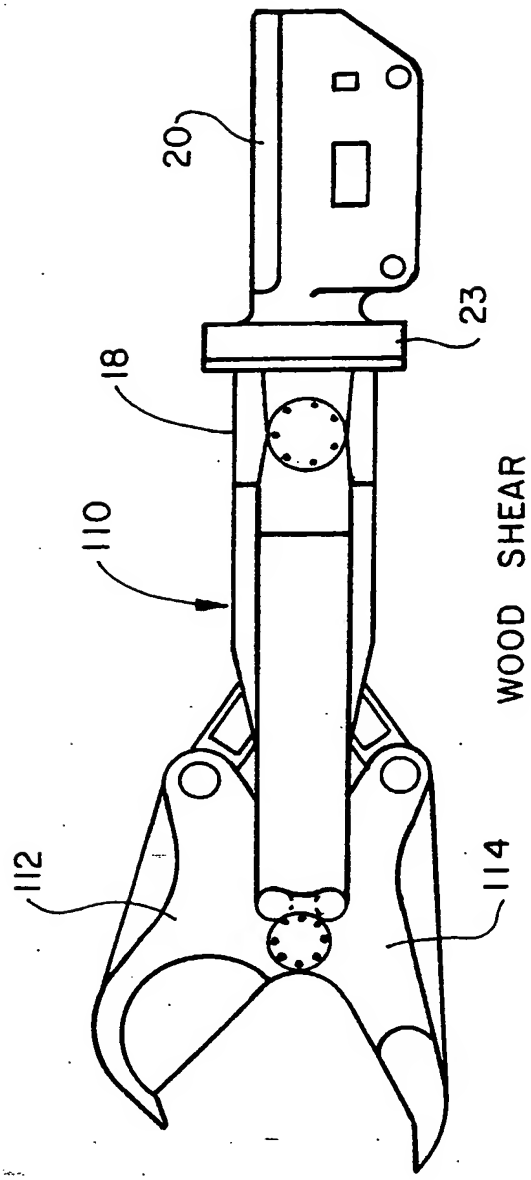


FIG. 18

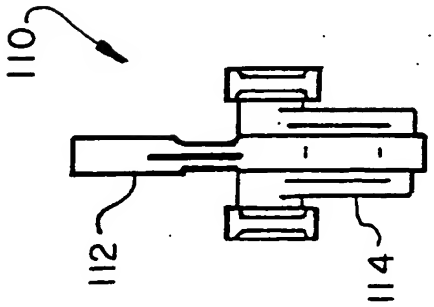


FIG. 19

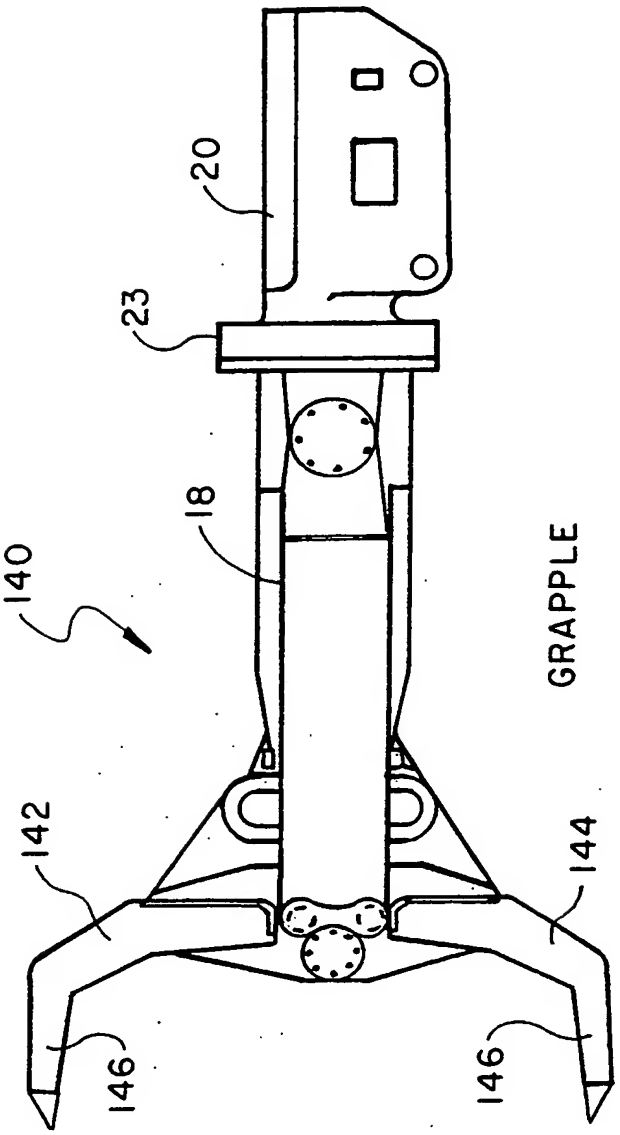


FIG. 20

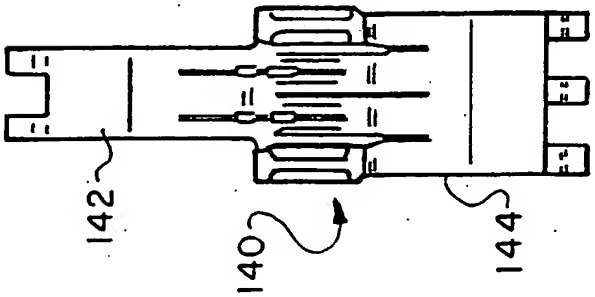


FIG. 21

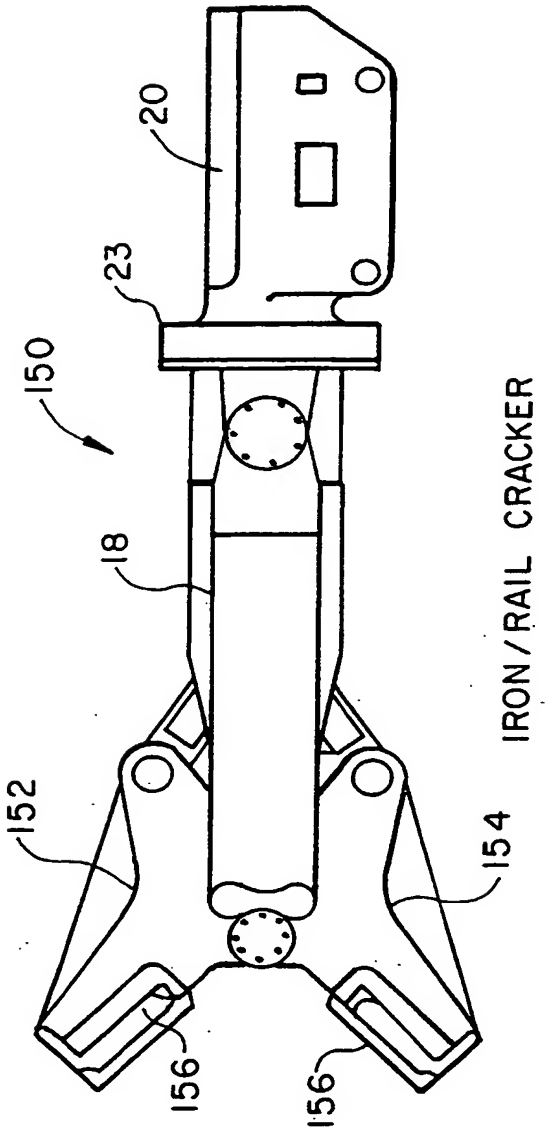


FIG. 22

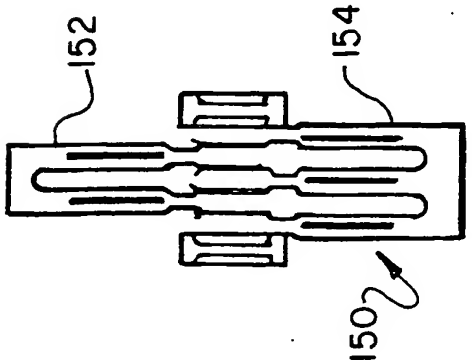


FIG. 23

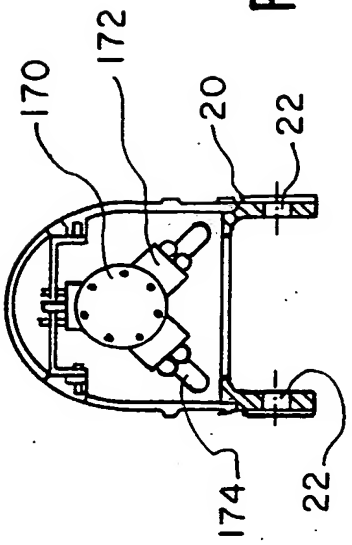


FIG. 24

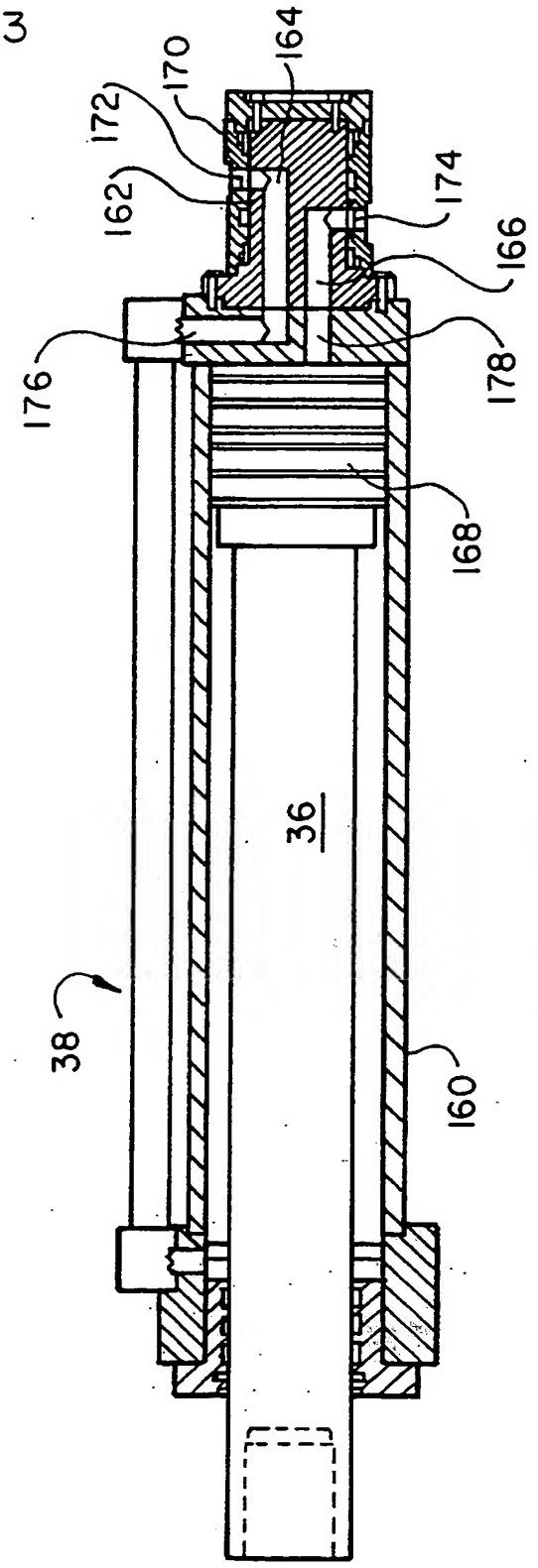


FIG. 25

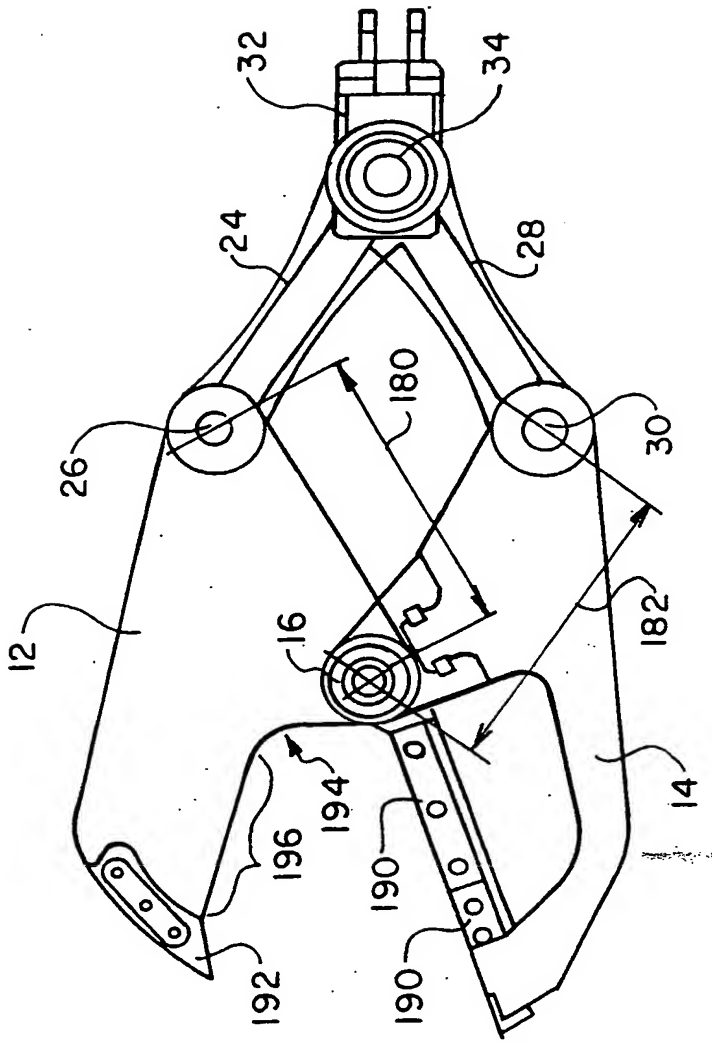


FIG. 26

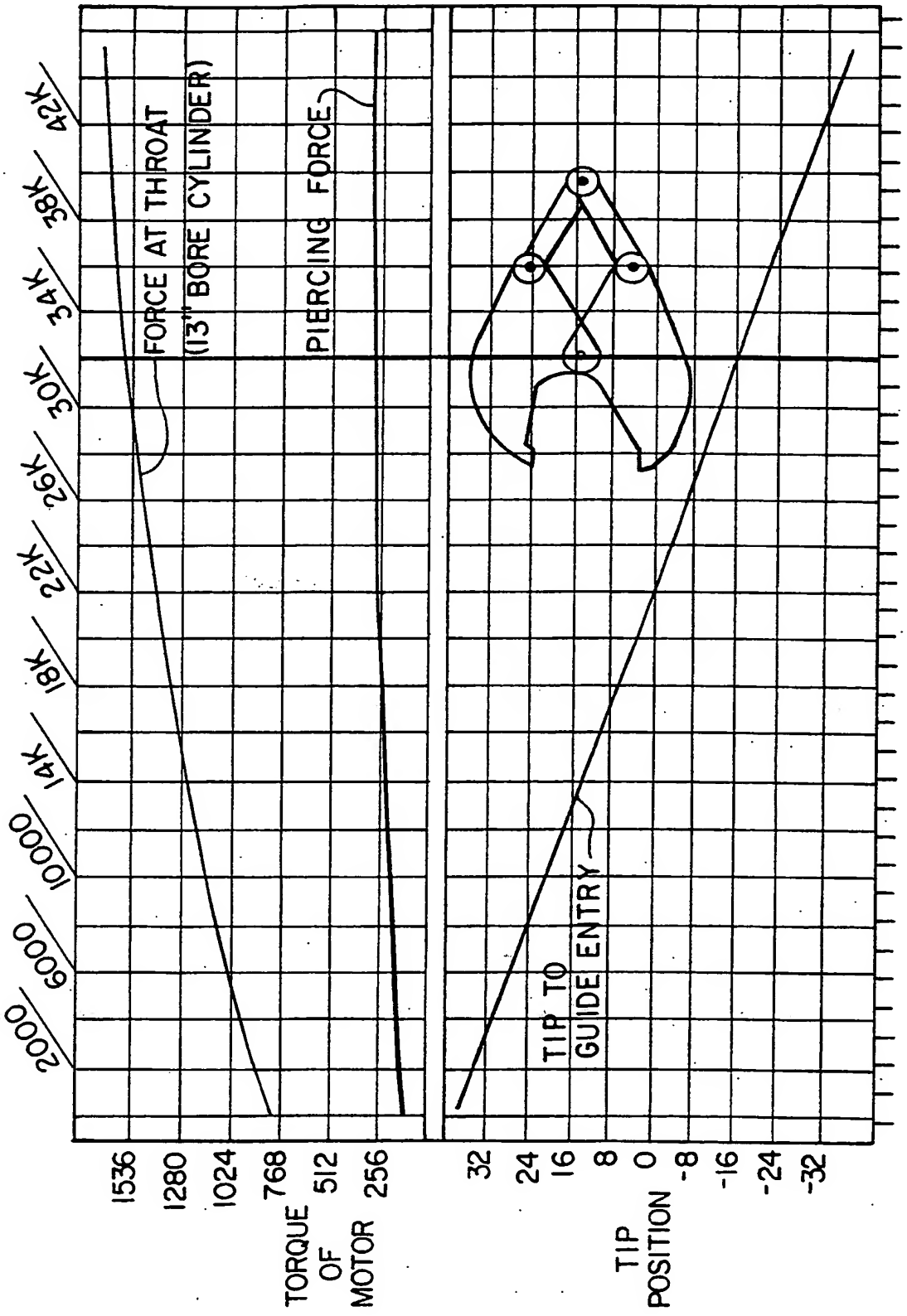

FORCE AT THROAT
(13" BORE CYLINDER)
PIERCING FORCE
42K
38K
34K
30K
26K
22K
18K
14K
10000
9000
8000
1536
1280
1024
768
512
256
TORQUE OF MOTOR
32
24
16
8
0
-8
-16
-24
-32
TIP POSITION
TIP TO GUIDE ENTRY
FORCE

FIG. 27a

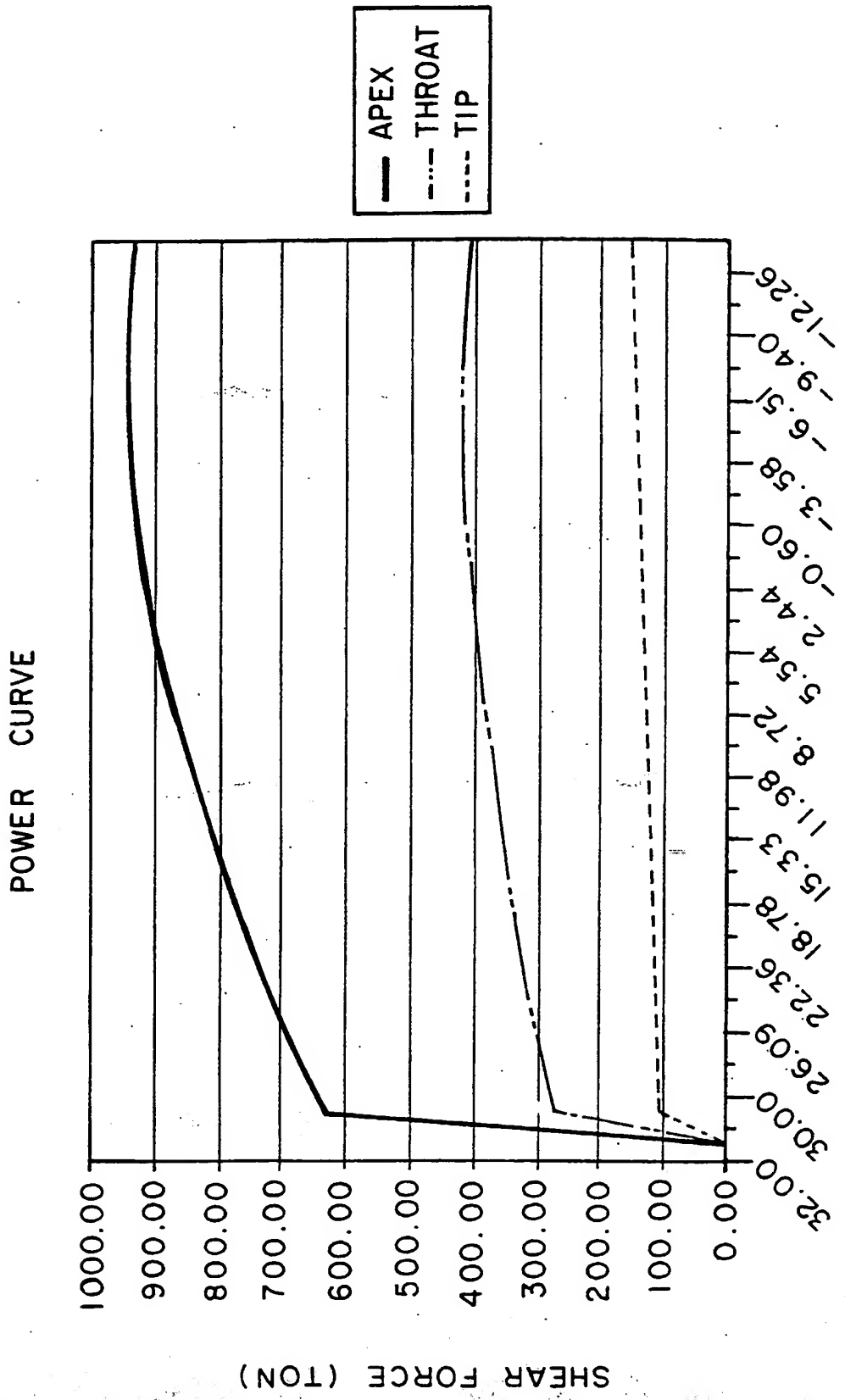

APEX
THROAT
TIP
POWER CURVE
SHEAR FORCE (TON)
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
SHEAR OPENING (IN)
-12.26
-9.40
-6.51
-3.58
-0.60
2.44
5.54
8.72
11.98
15.33
18.78
22.36
26.09
30.00
32.00

FIG. 27b

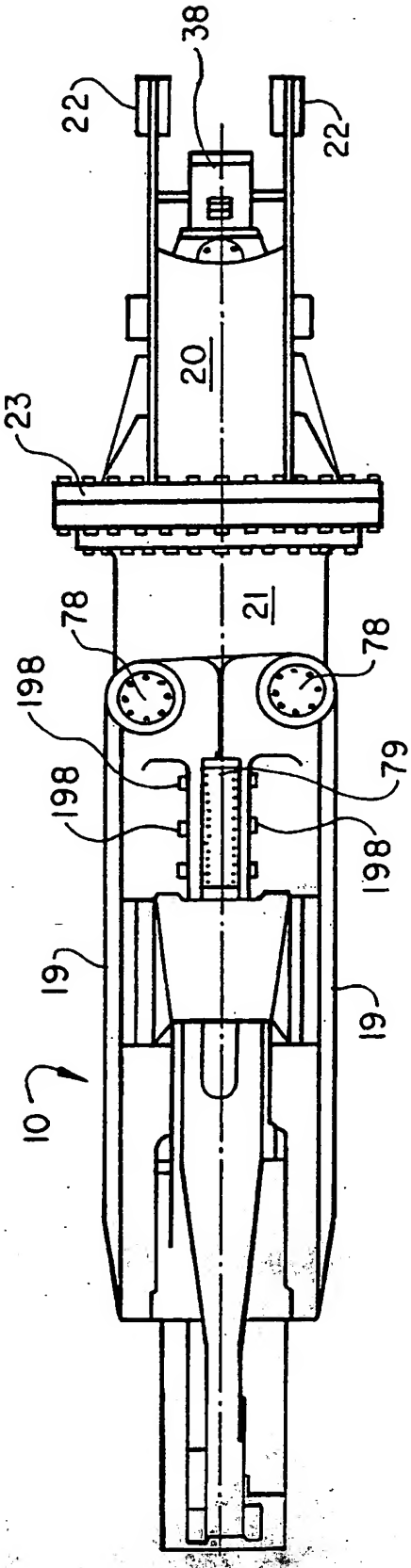

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FIG. 29

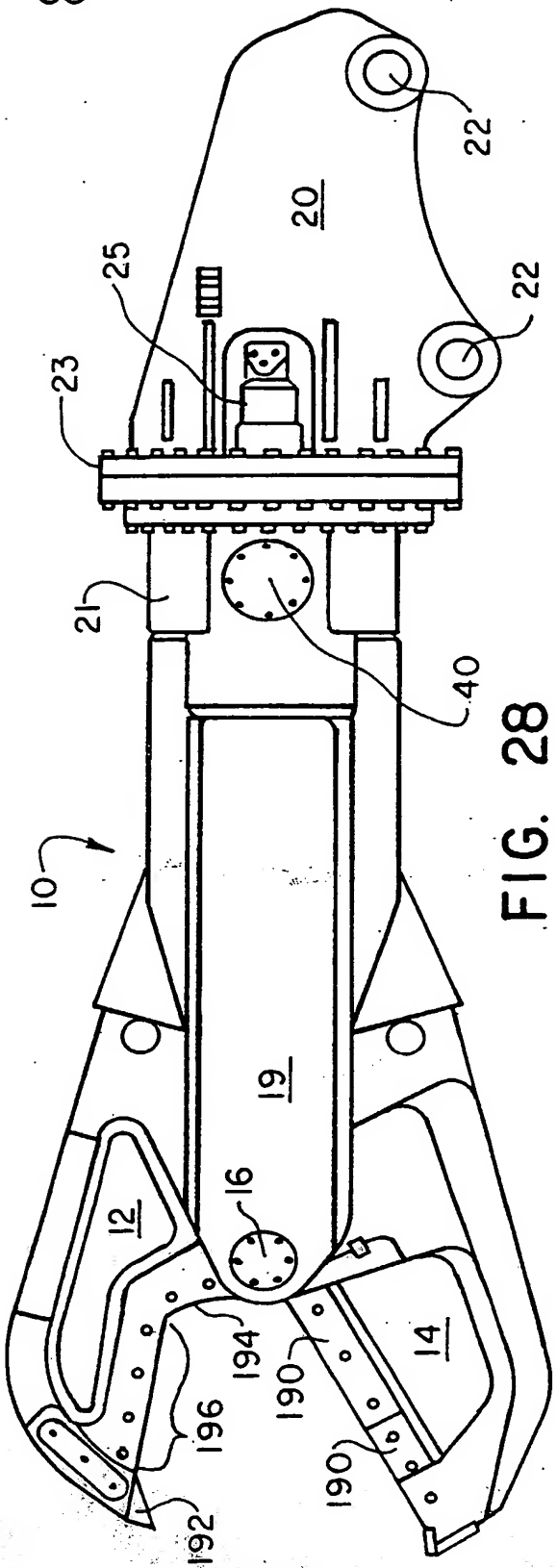
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FIG. 28

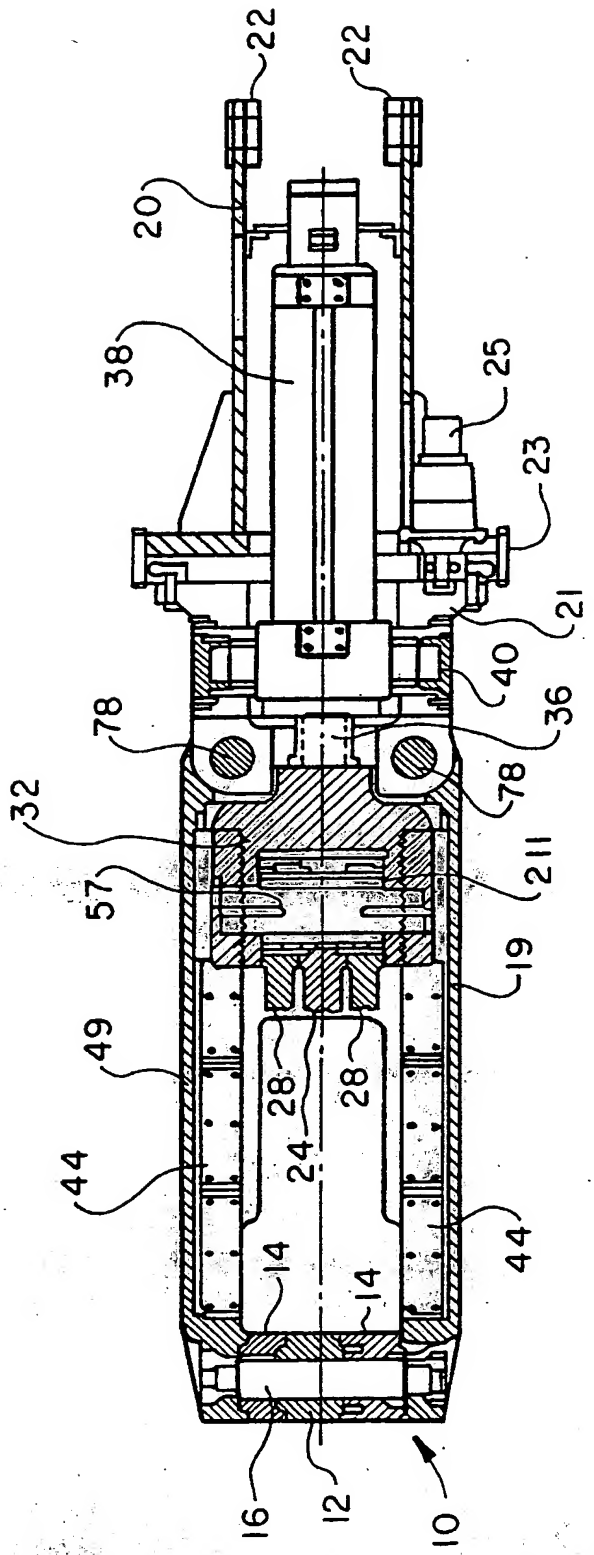
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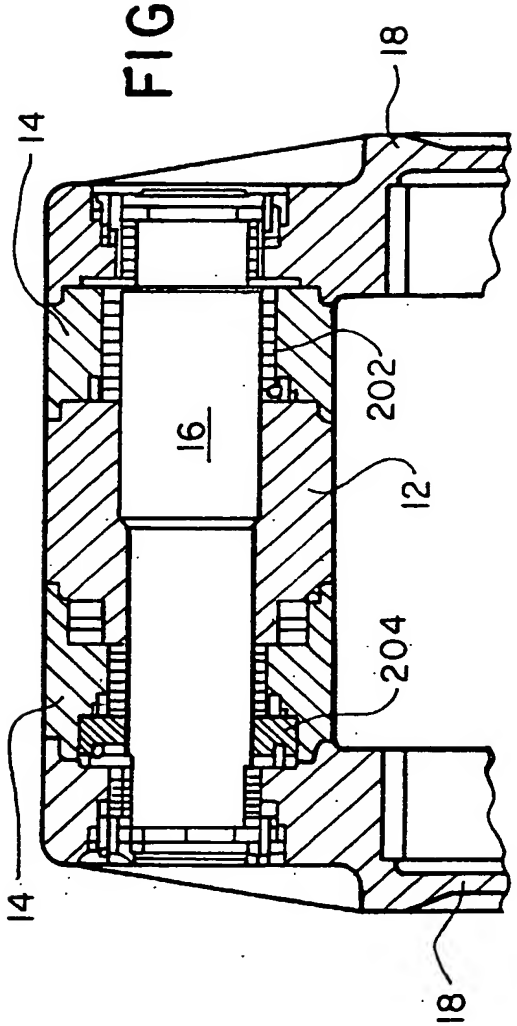
FIG. 30

FIG. 31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202
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204
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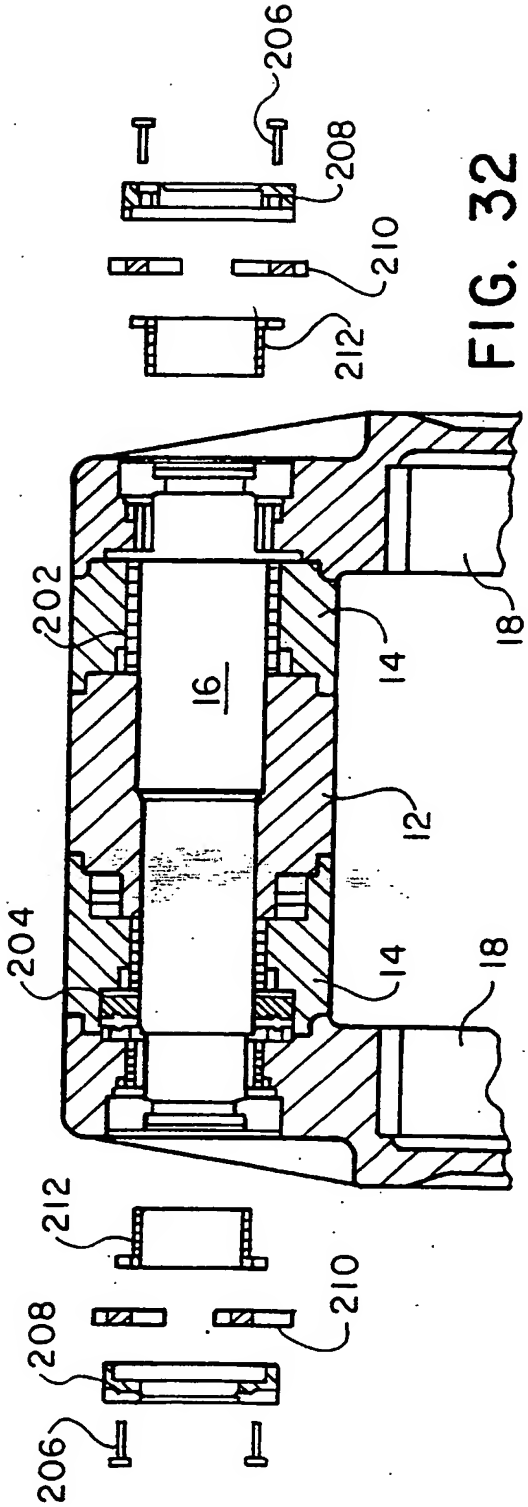
FIG. 32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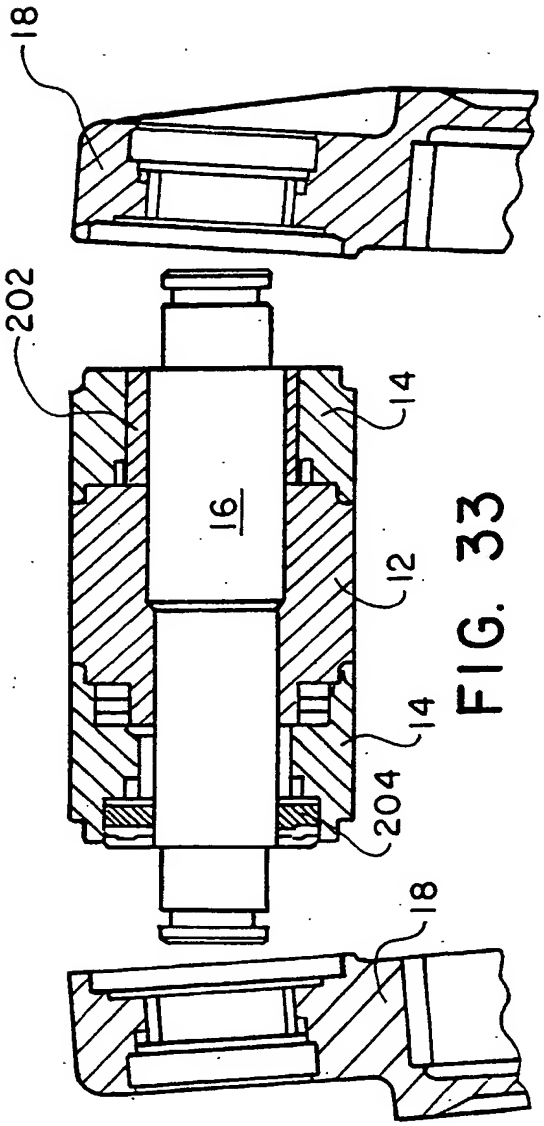

FIG. 33

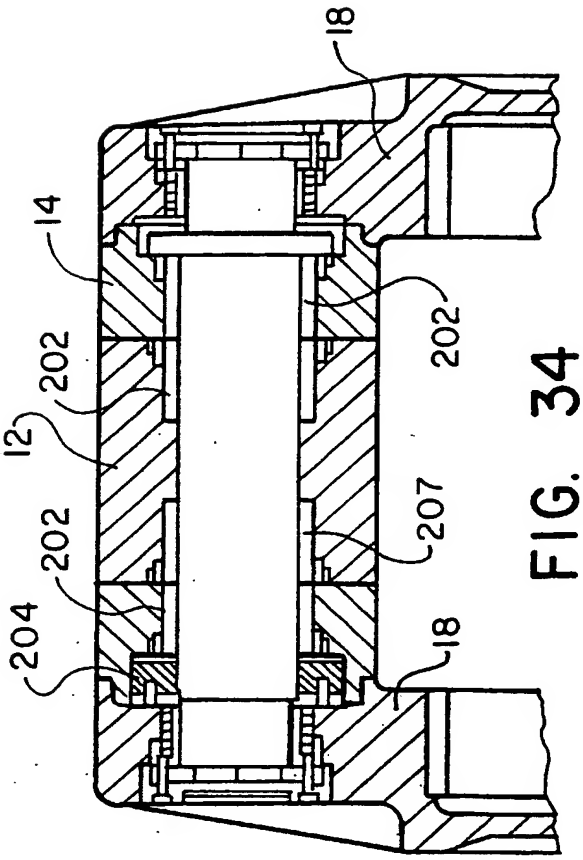

FIG. 34

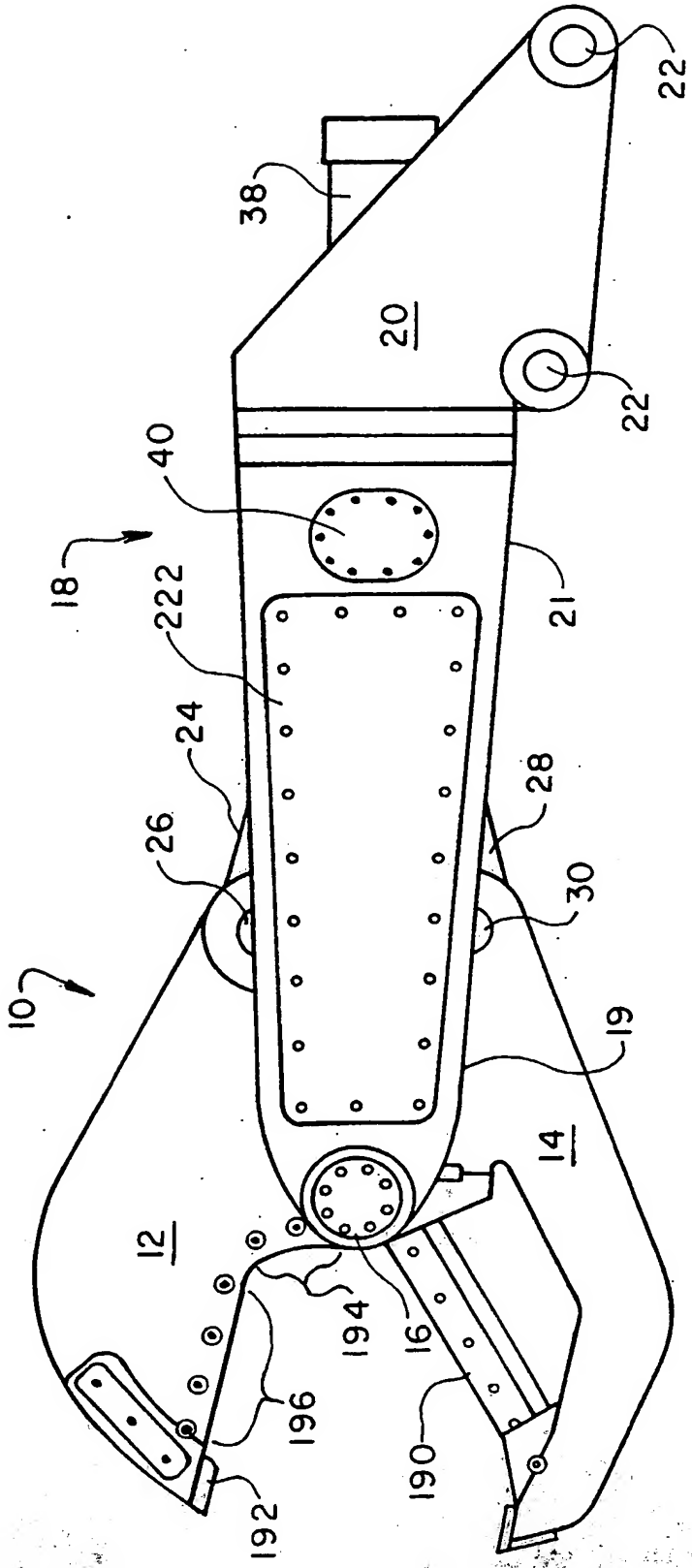

FIG. 35

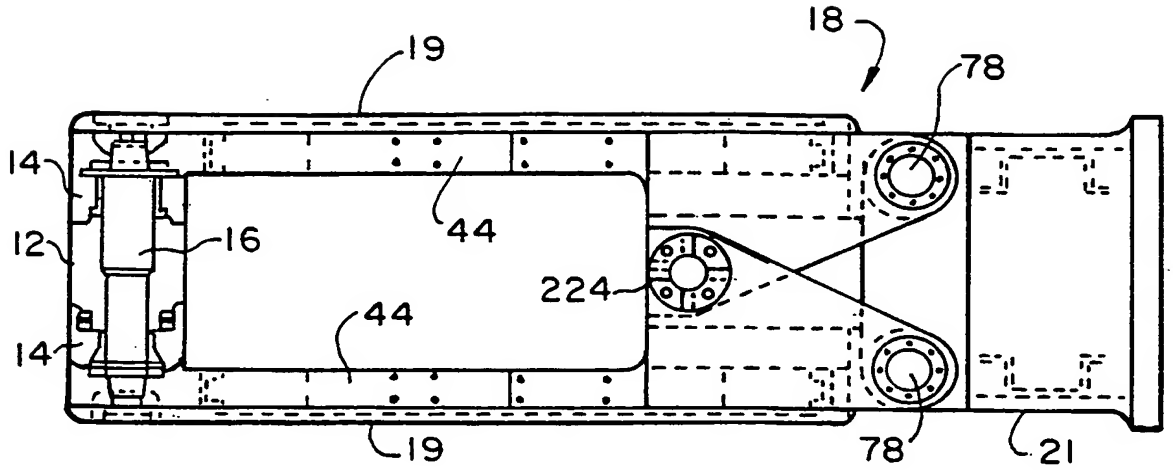

FIG. 36

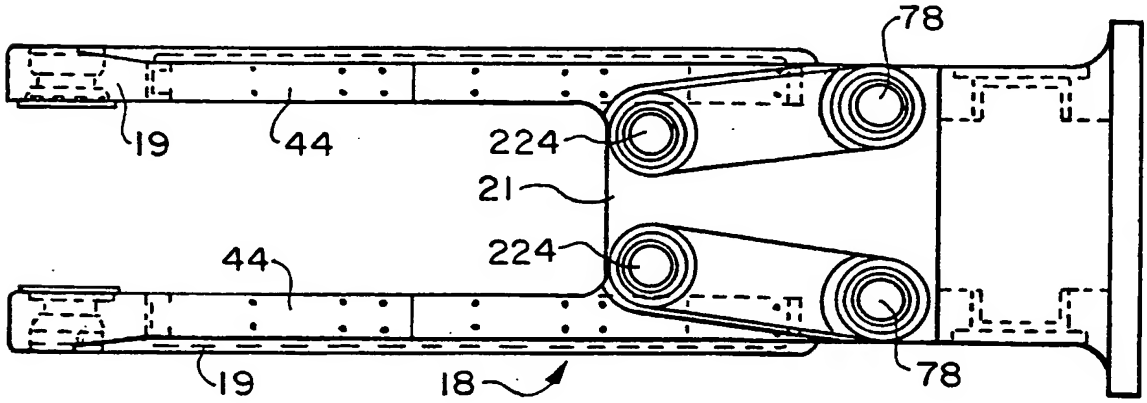

FIG. 37

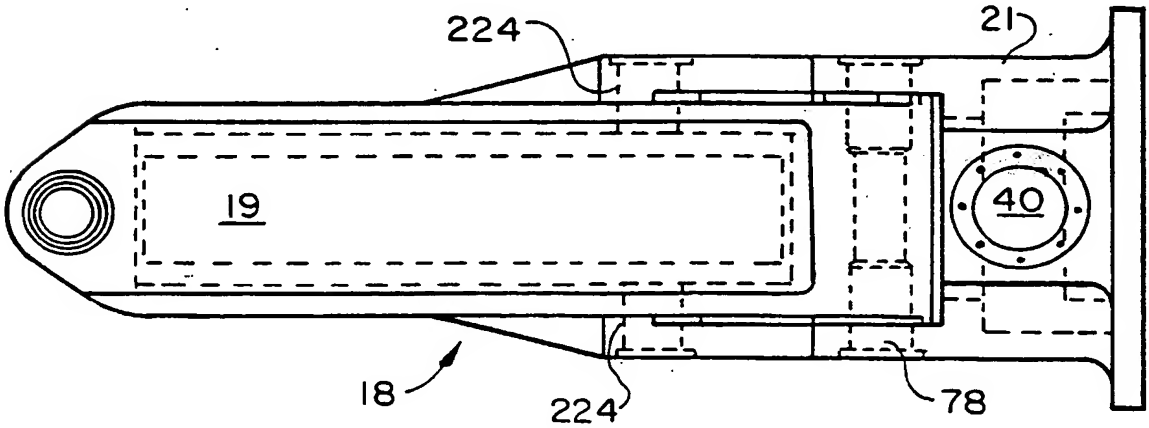

FIG. 38

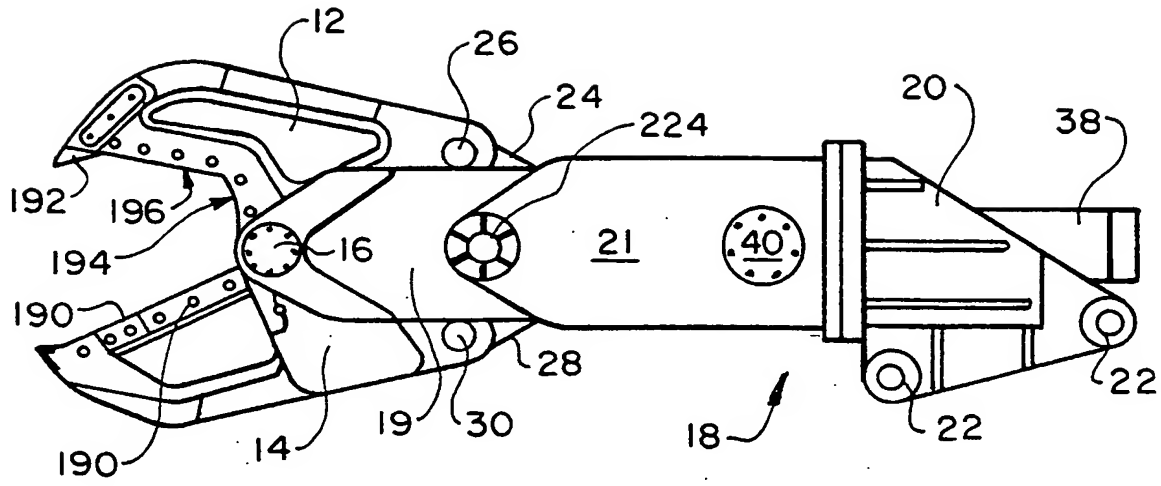
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FIG. 39

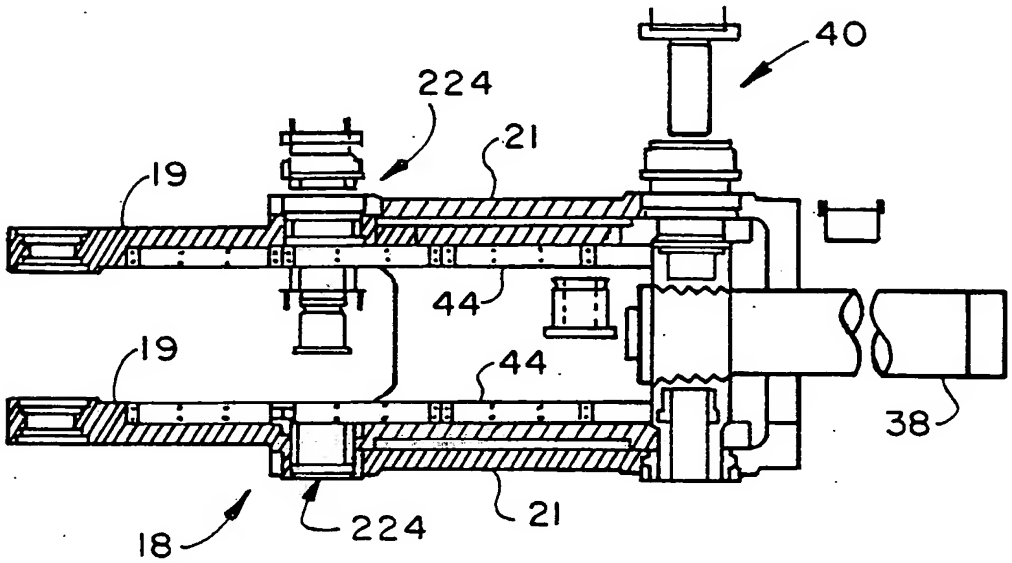
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FIG. 40

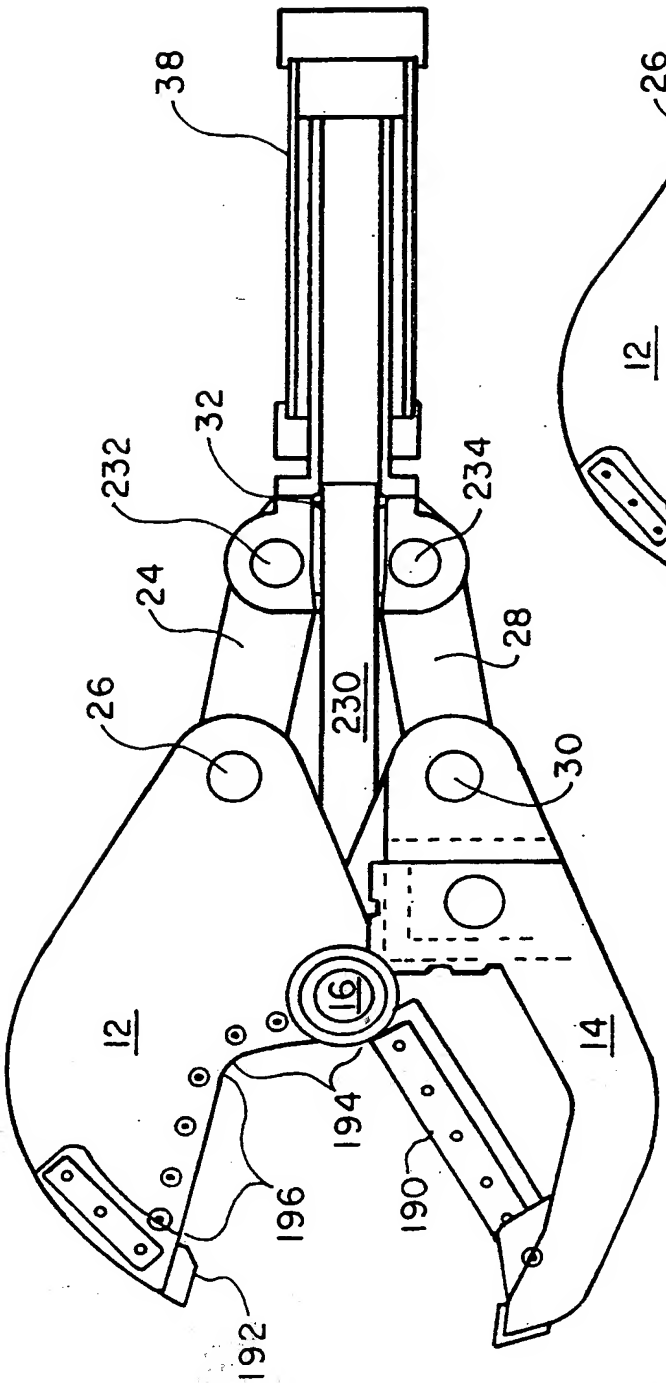
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FIG. 41

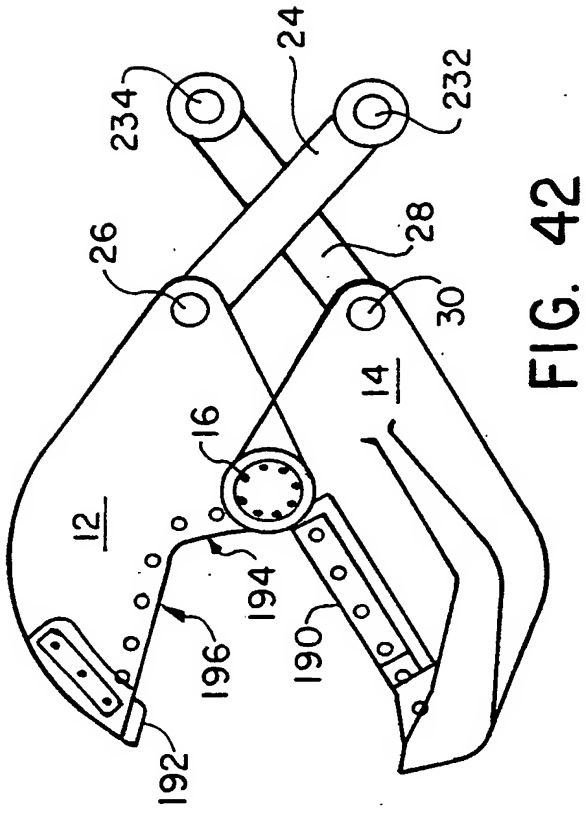
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FIG. 42

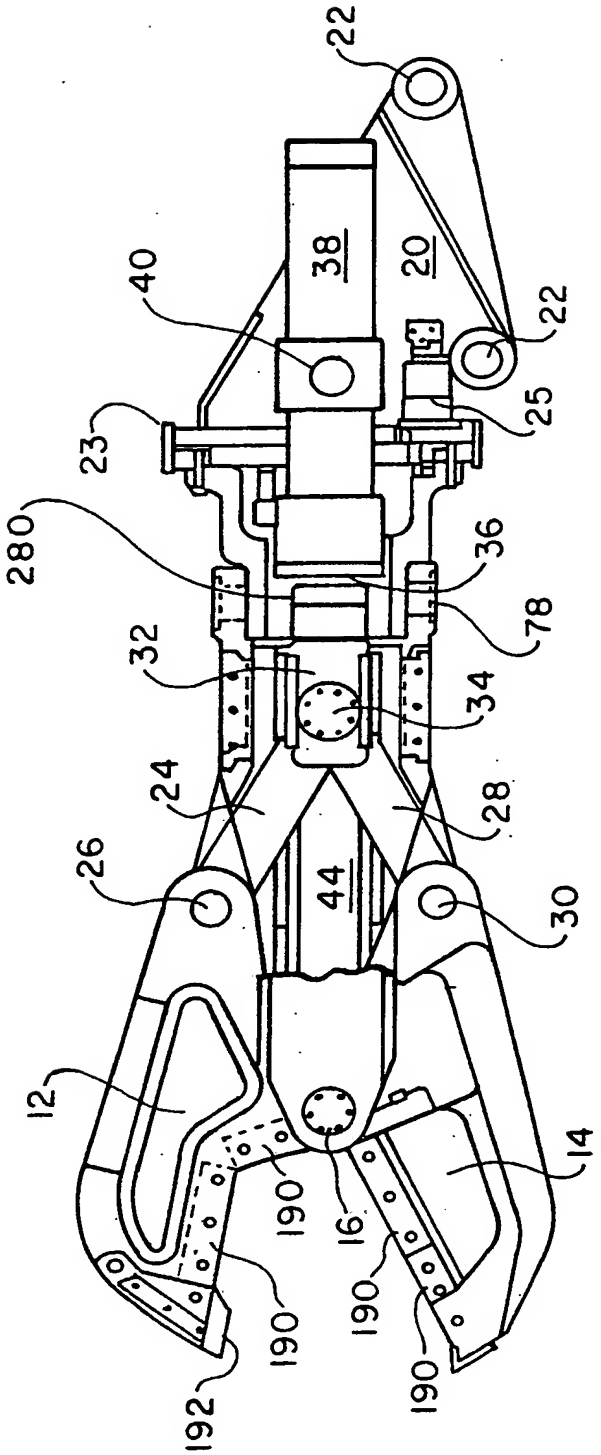
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FIG. 43

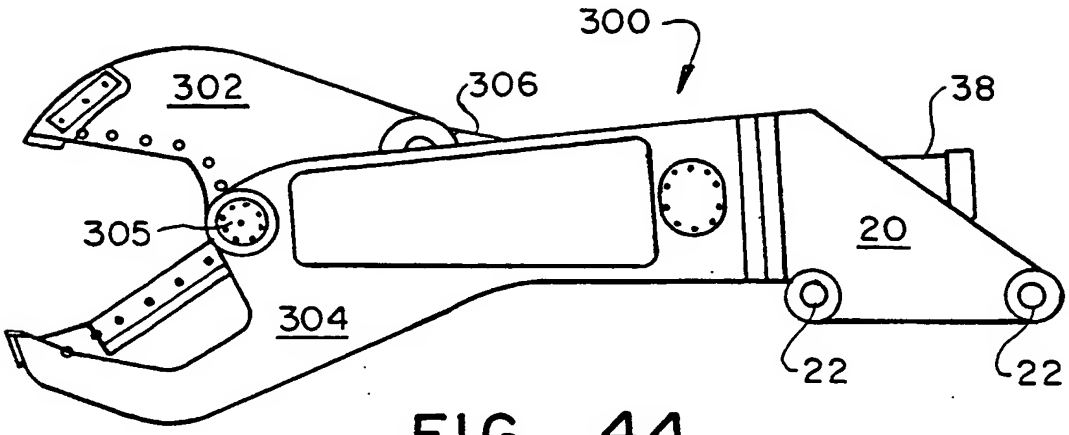

FIG. 44

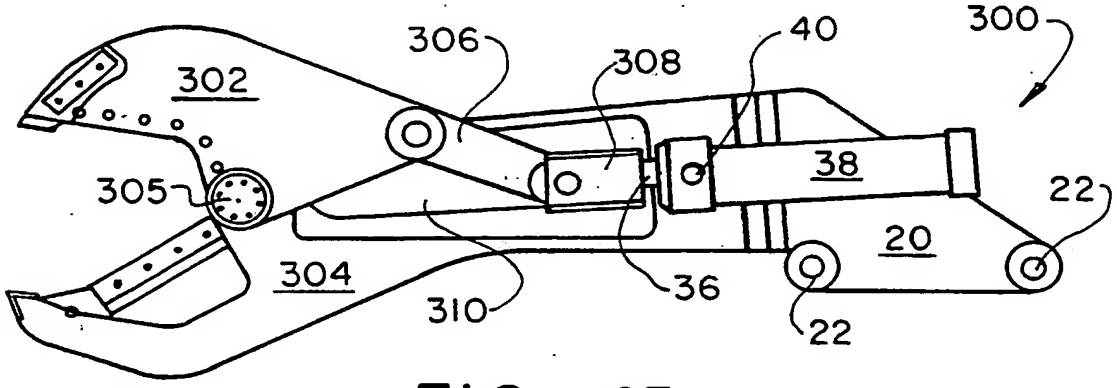

FIG. 45

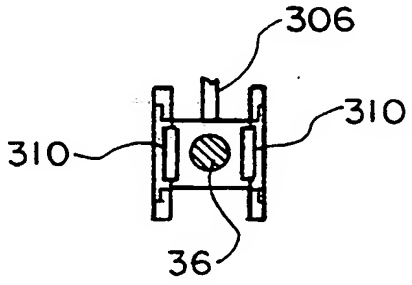

FIG. 46

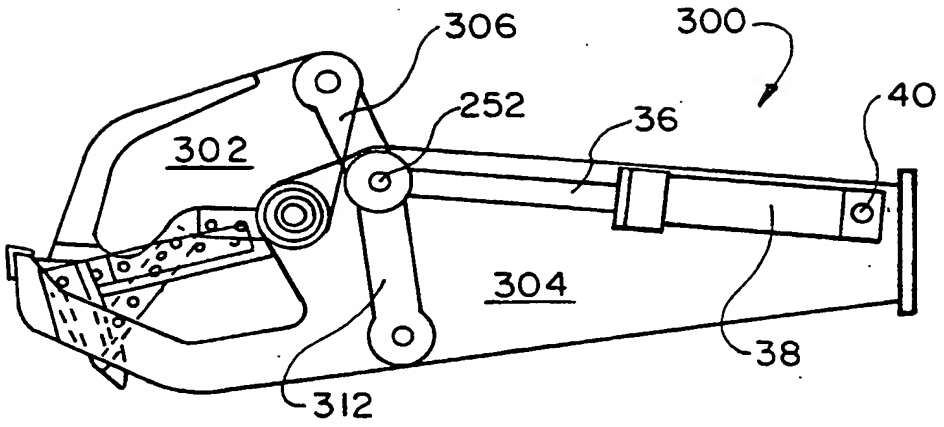

FIG. 47

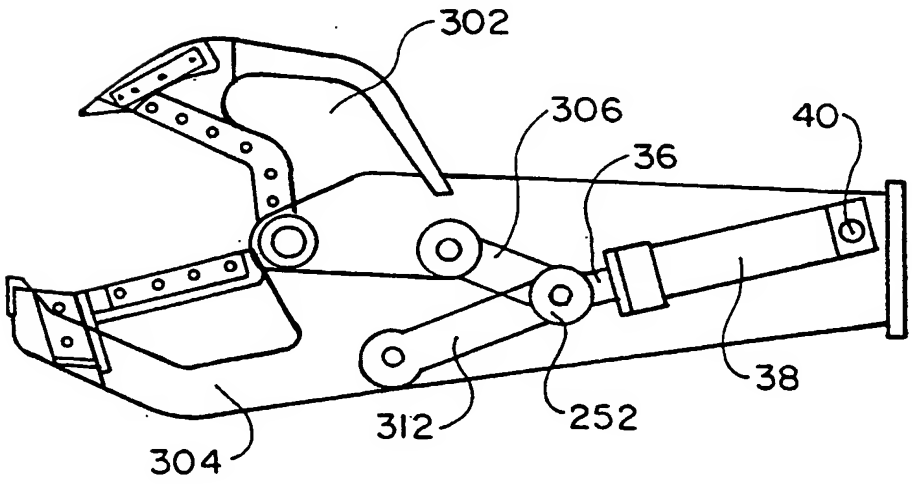

FIG. 48

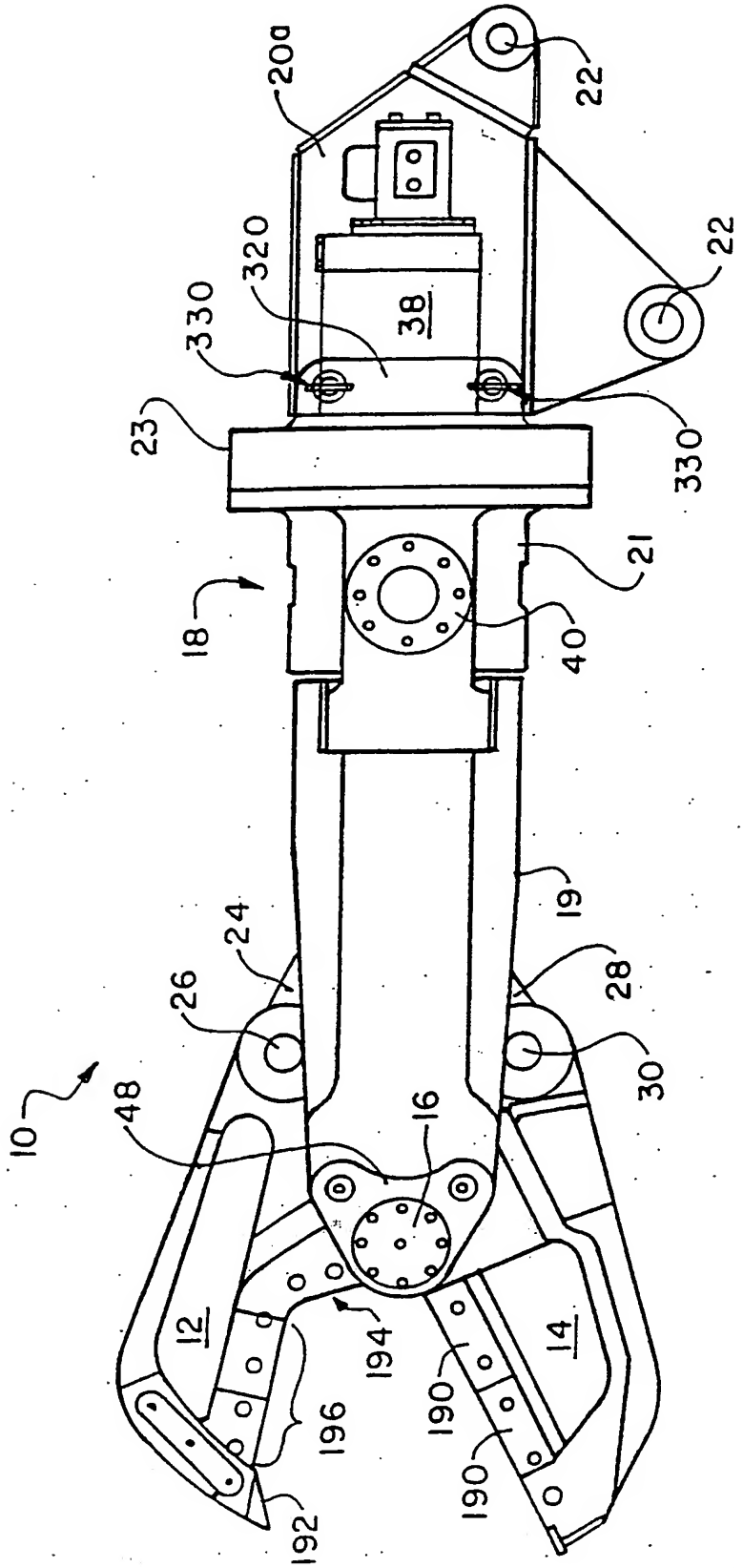
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FIG. 49

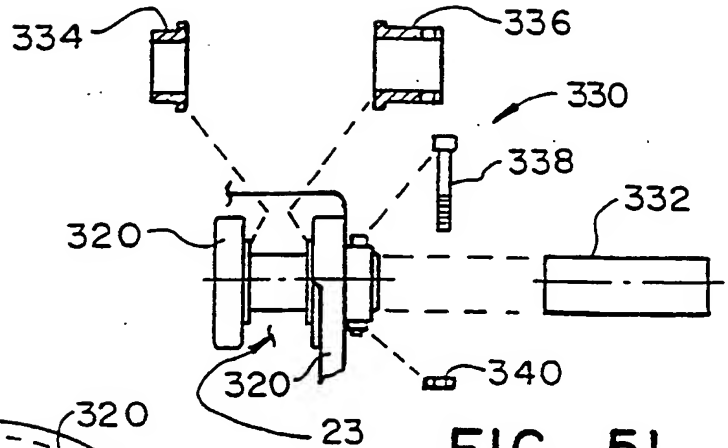

FIG. 51

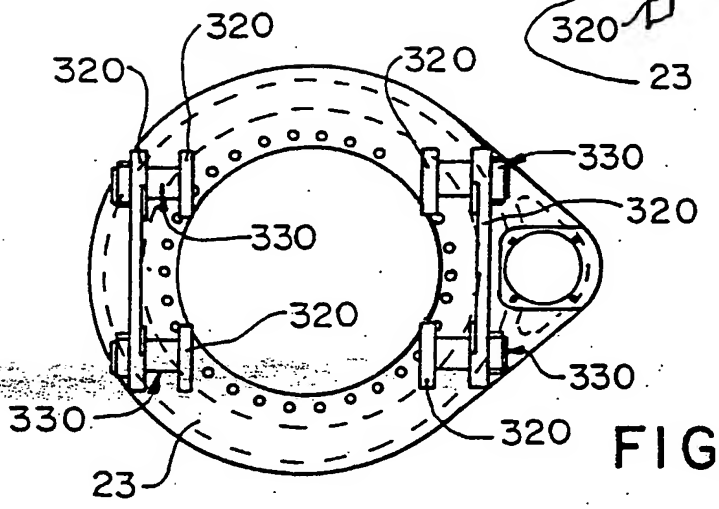

FIG. 50

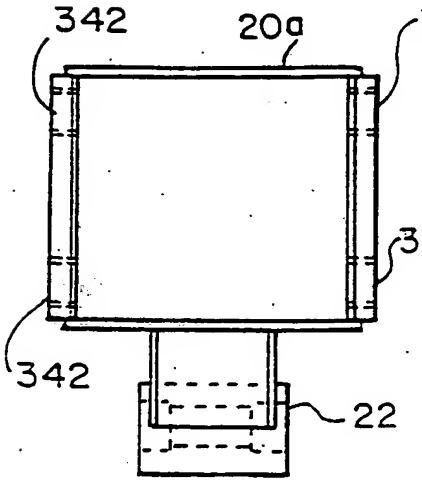

FIG. 53

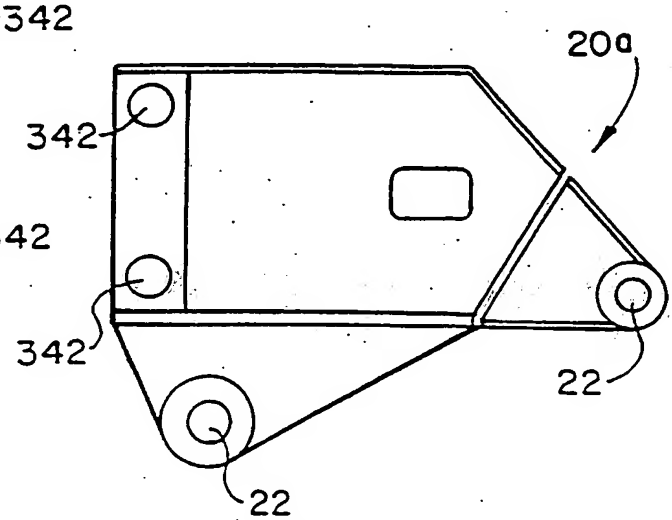

FIG. 52

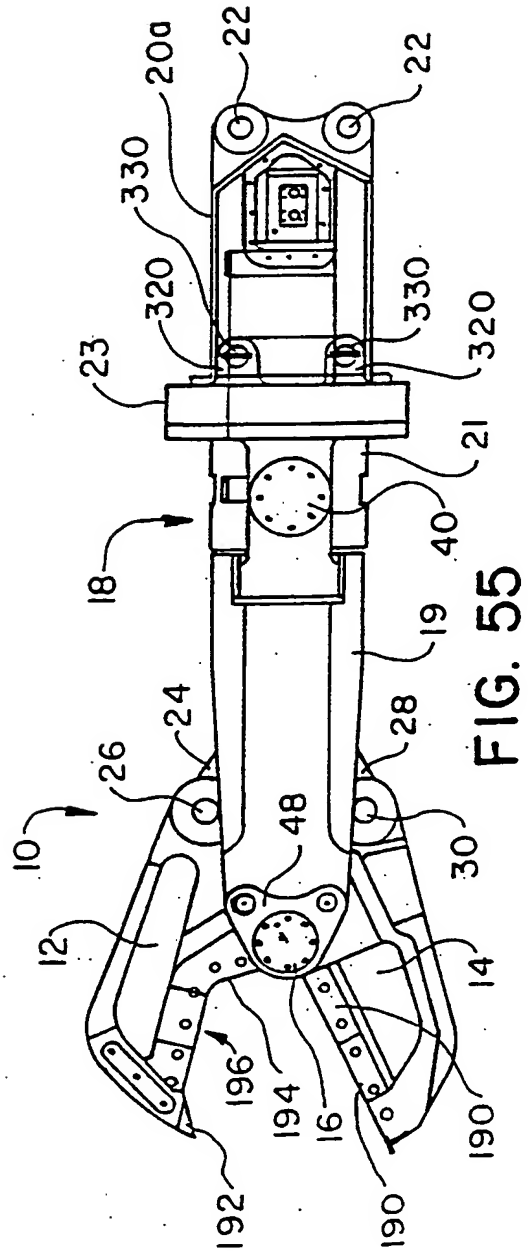
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FIG. 55

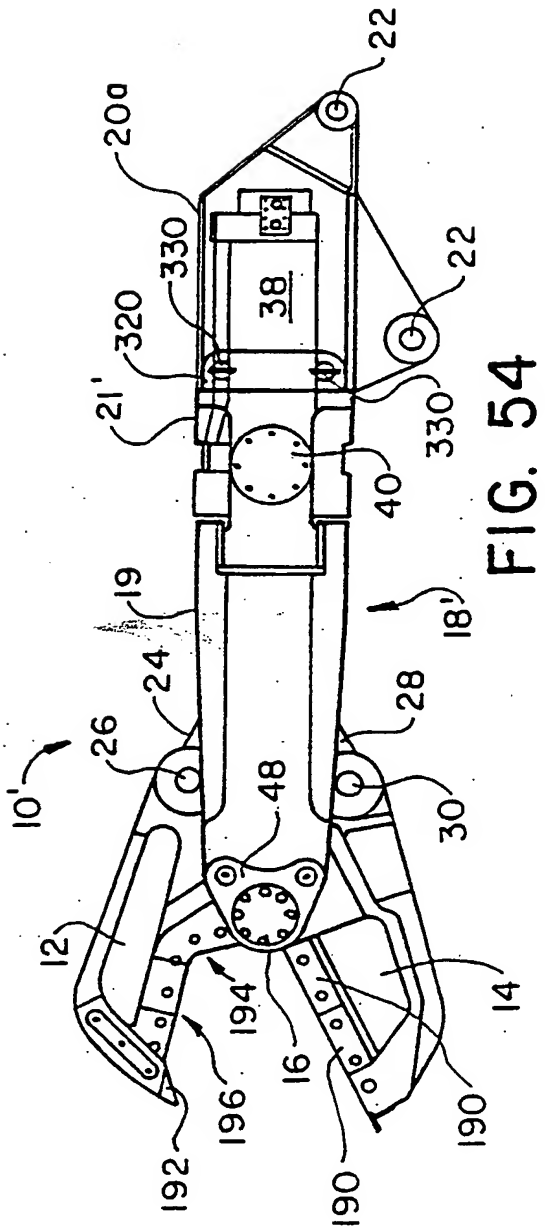
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FIG. 54

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/28367

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B02C 1/00
US CL : 241/101.73, 266; 30/134
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 241/101.73, 266; 30/134

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,738,289 A *(TAGAWA)* 14 April 1998, See Figure 1	1-75
X	US 5,636,802 A *(TAGAWA)* 10 June 1997, See Figure 3	1-75
X	US 4,890,798 A *(TAGAWA et al.)* 02 January 1990, See Figure 1	1-75
Y	US 5,243,761 A *(SULLIVAN et al.)* 14 September 1993, See Figure 4	1-75

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 DECEMBER 2000	25 JAN 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer WILLIAM HONG Telephone No. (703) 308-1148

Sheila Veley
Paralegal Specialist
Technology Center 3700

Form PCT/ISA/210 (second sheet) (July 1998)*